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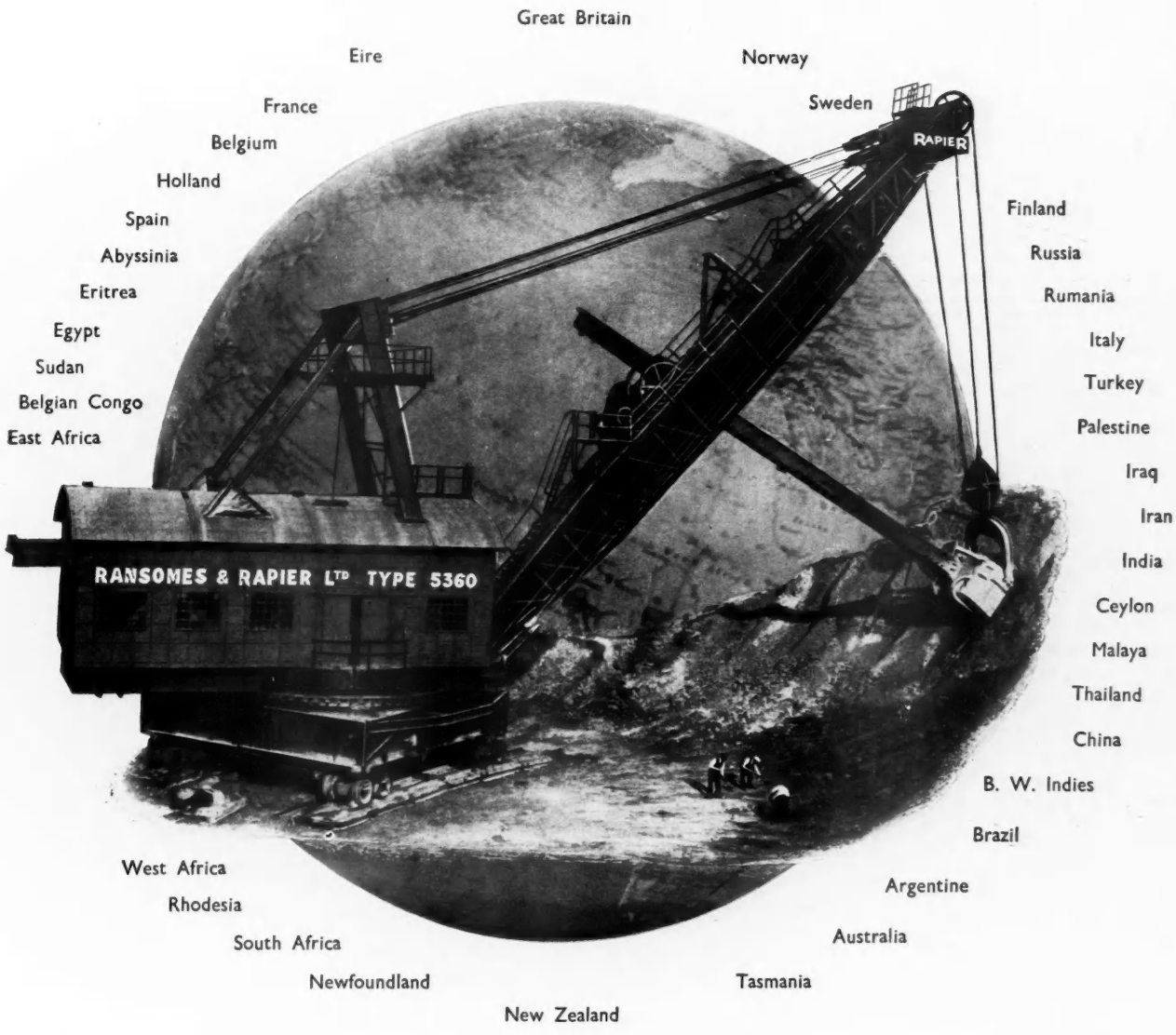

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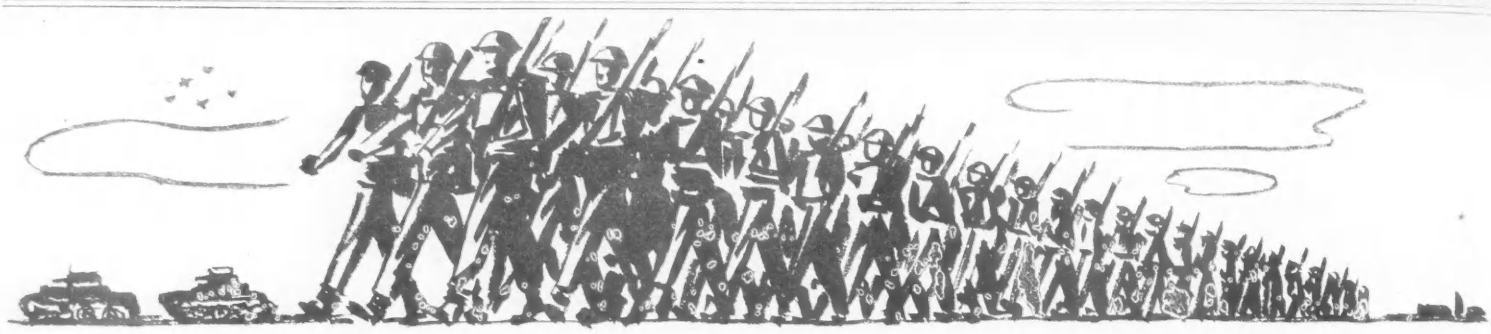

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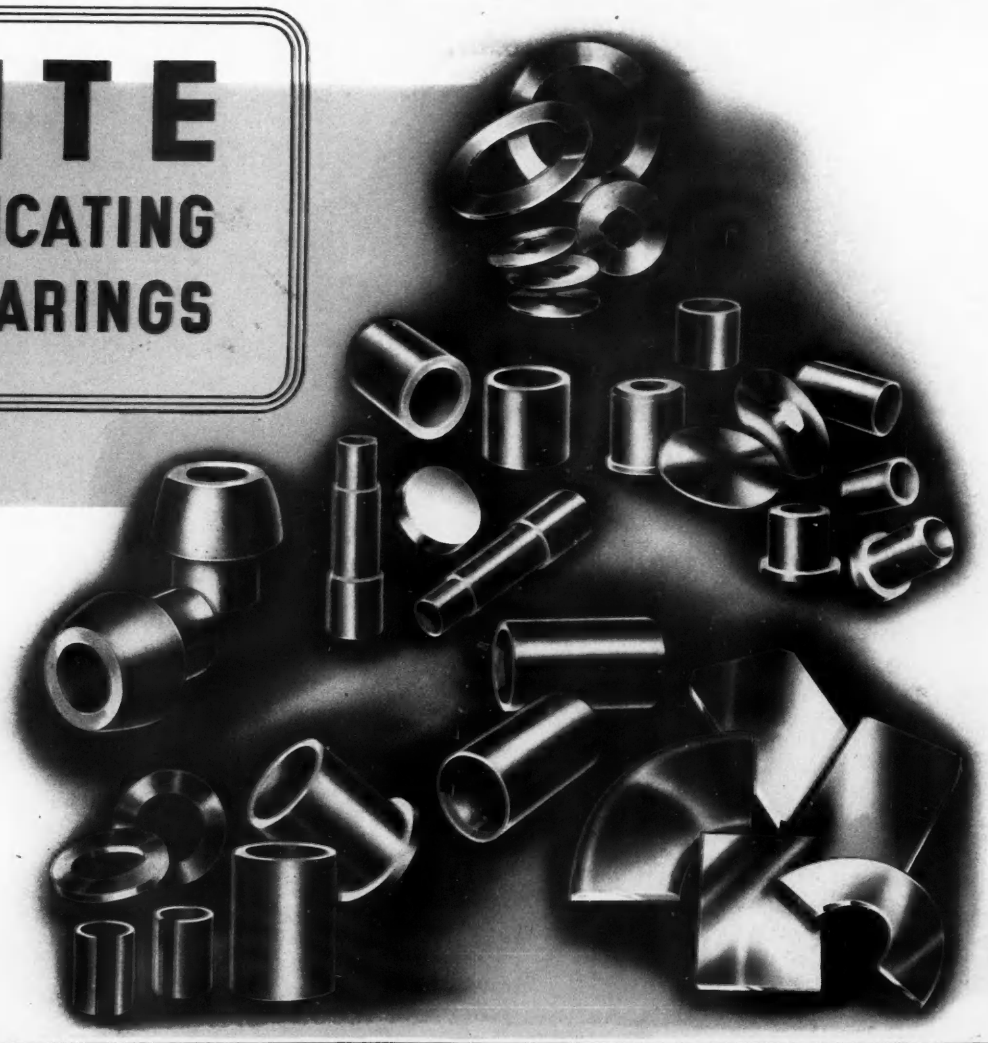

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A Seven-Day Journal

Ministry of Supply Departmental Changes

ON Monday, June 17th, a statement regarding the resignation of Mr. Arthur A. Rowse, Controller of Machine Tools in the Ministry of Supply, was made. Twelve months ago Mr. Rowse placed himself, in an advisory capacity, at the disposal of Mr. Burgin with regard to manufacture, more particularly in relation to machine tools. Shortly after the outbreak of war he assumed control of machine tools. During the period of his control there has been a marked increase in both British manufacture of machine tools, and the volume of importations of new and used machine tools from America. Feeling himself unable to agree with certain rearrangements Mr. Rowse tendered his resignation to Mr. Herbert Morrison, the Minister of Supply, which, after some consideration, was accepted. In advising Mr. Rowse that the Minister had accepted his resignation, Engineer Vice-Admiral Sir Harold Brown, Director-General of Munitions Production, added that the Minister did so with the greatest regret, and the fullest recognition of the splendid work Mr. Rowse had done. Sir Harold also expressed his personal appreciation of Mr. Rowse's loyal and unfailing help in the past strenuous months. The Minister has appointed Mr. Percy Mills to be Controller, and Mr. J. C. Blair to be Deputy Controller, of Machine Tools in the Ministry. Mr. Peter F. Bennett, Director-General of Tanks and Transport, has also placed his resignation in the hands of the Minister, who has accepted it, and has appointed Captain G. D. Burton, late R.E., the managing director of the Birmingham Small Arms Company, Ltd., to succeed him.

Increased Coal Production

IT is announced by Mr. D. R. Grenfell, the Secretary for Mines, that under the leadership of the Coal Production Council, presided over by Lord Portal, Production Committees have now been established in all the principal mining districts, with the object of taking every possible step in order to meet the urgent demand for more coal. In order to assist these Committees and to maintain close co-operation with the Mines Department and the Coal Production Council, the Secretary for Mines has appointed the following Coal Production Advisers for the districts named. Lord Portal is to continue to be Chairman of the Council, and other Advisers have been added to its membership. The newly appointed Coal Production Advisers and their districts are as follows :—England : North-Eastern, Mr. Clive Cookson ; North-Western, Sir Robert Burrows ; West Midland, Mr. J. Cadman ; and Yorkshire and East Midland, Mr. Owen V. Smith. Sir Nigel Campbell will act for the collieries of Scotland, and Lord Portal for the collieries of Wales. At a meeting held in Cardiff a special conference of miners' delegates approved a scheme which has been drawn up for the speeding up of coal production in South Wales. The scheme adopted provides for the reopening of closed pits, the return to work of thousands of unemployed miners, and the recall of colliers who are now working in other industries. The Welsh miners have also decided to work on Sunday nights for the duration of the war, and to suspend the application for holidays for two months. A further increase of at least 7½ per cent. is being worked for in the collieries of the Lancashire and Cheshire coalfield. At a meeting of the National Executive of Scottish Mineworkers, held on Monday, June 17th, in Glasgow, which was attended by Sir Nigel Campbell, it was stated that it was desired that the Scottish production should be increased by 15 per cent. or 90,000 tons weekly.

Technical Colleges and War Work

AN official announcement by the Board of Education points out that while the primary purpose of technical colleges is training of various kinds, the war has caused them to extend their activities. During the early months some of them began to do other work in their engineering departments to assist in the production of war material. The work of training does not occupy their plant for twenty-four hours a day, and some plant which is especially suitable for making tools, gauges, and jigs is not required for training. The marginal capacity of technical schools and colleges throughout the country is now being organised in producing war material and a number of them have started work. This use of technical college facilities must be dependent upon an adequate supply of suitable labour. It must be remembered that men cannot be withdrawn for this purpose from the regular industrial army engaged in the workshops and factories of the country. So far the labour is being found by the use of the staffs of the colleges, released by rearrangement of their other duties ; by the use of metalwork instructors with the necessary skill withdrawn temporarily from other kinds of schools ; by work on production of some of the trainees during their hours of training. These categories of workers by themselves alone will, in many areas, not be sufficient to keep the machines steadily at work full time, and nothing less than this can satisfy the consciences of anyone concerned with these institutions. It is, therefore, certain that in some colleges it will be possible to employ operators for some hours during the evening, even during the night, certainly during week-ends, and model makers should be able to make a valuable contribution to the national effort by the use of their spare time in this way. The production of gauges, in particular, is work which demands skill, patience, resourcefulness, and sometimes originality, and with the aid of good machine tools available in technical colleges most of the ends desired are within the reach of those expert "amateurs" who maintain the high standards of model making in this country.

Federation of British Industries and the Present Crisis

As President of the Federation of British Industries, Lord Dudley Gordon has, at this grave crisis in our history, sent a message of encouragement to all engaged in industry. "The Federation of British Industries," he says, "as the mouthpiece of industry, is in constant and close contact with the Government, and has from the beginning of the war pledged the effort of organised industry to the service of the nation. The country now has to bear the full strain of whatever the future may bring, and we do so with the knowledge that in the true spirit of federation those engaged in industry have responded to the call of the Government to sink all individuality and self-interest in the task of serving the nation. Industry has to supply first of all the instruments of war and other supplies so urgently needed for our Fighting Forces, and at the same time to continue in confidence and strength the means of keeping in being the life of the nation which depends on those forces, who in their turn depend on us. In this spirit, industry must still further increase the great effort now being made, so that we may resist all assaults that assail us, and by our tenacity of purpose retain the freedom which has been handed down to us."

Railway Wages

AT a meeting which took place on Monday last, June 17th, between representatives of the railway companies and the railway shopmen's unions, it was decided that railway shopmen are to receive an extra 3s. per week, in addition to the existing war bonus of 5s. After some discussion it was agreed that the advance of a further 3s. in addition to the existing bonus of 5s., making 8s. in all, shall be considered a full settlement of the claim for an advance of 10s. a week which was made by the railway workshop staffs earlier in the year. It was further agreed that proportionate advances are also to be made to the wages of women and juniors. It will be recalled that awards of a 3s. a week advance to men in the traffic grades of railway service were recently agreed upon, and that this advance makes a total of 7s. together with that made in January last. As already recorded in our columns, the clerical railway staffs have also received an increase of £8 a year, which came into operation at the beginning of the present month.

British Naval Losses

IN the Journal note on British Naval strength, which was published in last week's issue, we briefly referred to the recent loss of the aircraft carrier H.M.S. "Glorious" and the two destroyers H.M.S. "Acasta" and H.M.S. "Ardent." The "Glorious" was a sister ship to the "Courageous," which was sunk last year. She was built by Harland and Wolff Ltd. at Belfast in 1910, and was converted to an aircraft carrier in 1916. She had a displacement of 22,500 tons and had a carrying capacity for forty-eight aircraft. The destroyer "Acasta" was built by John Brown and Co., Ltd., at Clydebank in 1930 and had a displacement of 1350 tons. Her propelling machinery comprised a twin-screw arrangement of geared turbine machinery, including Brown-Curtis high-pressure turbines and Parsons low-pressure turbines, taking steam from three-drum type Admiralty boilers. The "Ardent" was a ship of the same class, built by Scott's Shipbuilding and Engineering Company, Ltd., of Greenock. The loss is also announced of the anti-aircraft ship H.M.S. "Calypso," which was sunk in the Mediterranean by an Italian U-boat. She was built and engined in 1917 by Hawthorn, Leslie and Co., Ltd., as a cruiser, and was due to be scrapped under the post-war London Naval Treaty, but in 1936 was retained for further service and was equipped as an anti-aircraft ship. She had a displacement of 4180 tons and was propelled by Parsons geared turbines, taking steam from Yarrow oil-fired boilers. In home waters the two Admiralty trawlers H.M.S. "Myrtle" and H.M.S. "Ocean Sunlight" were sunk by enemy mines. Other losses to be recorded include the armed merchant cruiser "Carinthia," formerly a Cunard liner, which was torpedoed by a U-boat and subsequently sank. She had a measurement of 20,277 gross tons and was built and engined by Vickers-Armstrong, Ltd., at Barrow-in-Furness in 1925. The transport vessel "Orama," a former Orient liner, built and engined by Vickers-Armstrong, Ltd., in 1924, has also been lost, as also has the oil tanker "Oilpioneer," a vessel of 5666 tons, built by Swan, Hunter and Wigham Richardson, Ltd., for the service of the British Oil Shipping Company, Ltd., in 1928. On Friday evening, June 14th, the Admiralty announced the loss of the armed merchant cruiser H.M.S. "Scotstoun," which was sunk on Thursday, June 13th, by a U-boat. This ship was formerly the Anchor liner "Caledonia," with a gross tonnage of 17,046. She was built and engined by Alexander Stephen and Sons, Ltd., of Linthouse, Govan, in 1925.

Garages and Munition Work

IT is announced by the Institution of Motor Engineers, of 19, Charing Cross Road, London, W.C.2, that its scheme for adapting garages for munition work has achieved such success that it is to be extended. As a beginning, four factories run by private capital have been set up, and are now engaged in the production of shell cases. Realising that there are throughout the country many garages which are out of service, the Institution formulated a scheme by which it was hoped to pool the resources of those in the same area. Under the scheme it was proposed to assemble all available tools in one or more convenient works, and to place them at the service of garage proprietors. In many cases it has been possible for the owners of plant such as lathes, drilling machines and other machine tools to operate them at centralised premises, the workmen being paid at the standard rates stipulated by the A.E.U. The first of the new experimental factories, it is announced, is now in course of completion in one of London's southern suburbs, and an organisation has been set up by the Institution to supply blue-print drawings and to give technical assistance in order that overhead costs may be kept down. No less than 37,000 letters, we learn, have been received by the organisation from proprietors of garages, which might be used if suitable pooling arrangements could be made. This interest has encouraged the organisers to go ahead with the scheme. Many owners of garages state that they have one or two machines, which, if others could be obtained, would enable them to turn an idle shop into a busy munition works producing vital components for aircraft. Under the scheme, the country has been divided into seventeen areas, and in each area it is proposed to convert the big garages into a factory which could be equipped with the necessary machinery loaned from the smaller garages in the surrounding district.

Export Groups for Electrical Machinery and Apparatus

SOME time ago it was officially announced that two main Export Committees had been formed in the electrical industry to deal with the two principal branches in the industry, namely, electrical machinery, and electrical goods and apparatus. The industry is informed that the following sectional export groups have now been formed under the ægis of the Electrical Machinery Export Committee, others being in the course of formation ; turbines, covering steam turbines, turbine reduction gear, turbine-driven generators, condensers, turbo-blowers and compressors ; electric traction apparatus ; A.C. and D.C. electric motors and generators ; transformers ; and switchgear, both heavy and medium. The Secretary of the Electrical Machinery Export Committee, and of the Sectional Export Groups named above, is Mr. A. G. Seaman, M.I.E.E., 36, Kingsway, London, W.C.2. In a similar way, the following Sectional Export Groups have been founded under the ægis of the Electrical Goods and Apparatus Committee :—Heating, cooking, and domestic electrical appliances ; electrical wiring accessories ; fans and fractional H.P. motors ; electric water heaters and temperature-control apparatus ; insulators and insulations ; and conduit fittings. The Secretary of the Electrical Goods and Apparatus Export Committee, and of the Sectional Export Groups above mentioned is Mr. Felix A. Rogers, 36, Kingsway, London, W.C.2. It is open to all bona fide manufacturers in Great Britain, who export or intend to export these products of their manufactures, to apply to the appropriate Secretary named above, for membership of the desired sectional group or groups.

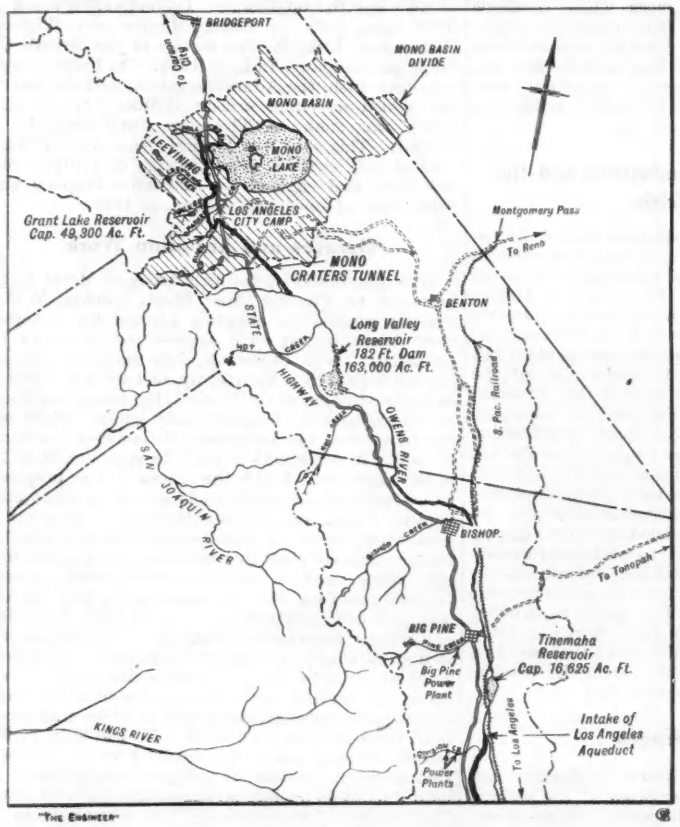
The Mono Basin Project

No. I

THE Mono Basin project is the lesser known of Los Angeles' efforts to assure an ample water supply for its expanding population. Despite the benefits that will accrue to the city through the completion of the Colorado River aqueduct, Los Angeles is further preparing to meet its water needs four decades hence. The Mono Basin project promises to be a substantial means to that end.

Work on the Mono Basin project has been under way since 1934, when tunnel-driving was started in the Sierra Nevada Mountains in order to link the Mono Basin with the Owens River. The basin is approximately 350 miles north of Los Angeles, and has a length of about 47 miles, and a width of 22 miles. The surface of the lake is about 6400ft. above sea level, and some of the neighbouring peaks rise to a height of more than 13,000ft. The region is dotted with numerous extinct craters. Mono Lake, exclusive of its two islands, has an expanse of nearly 87 square miles and is fed by several streams that descend the western slopes of the basin, and by springs near the western shore or springs that have their outlets in the bed of the lake. Little water reaches the lake from the eastern mountain slopes, which are for the most part devoid of vegetation.

All the subterranean waters carry dissolved salts, and the lake water is much too saline for either industrial or domestic use. Furthermore, the rate of evaporation is such as to induce a gradual lowering of the lake level while incidentally increasing the salinity. The creeks that deliver water from the western slopes carry untainted water that has its source mainly in the snow deposited on the shoulders of the Sierra Nevadas each winter. The run-off contains an average of only 2·52 grains of solids per U.S. gallon compared with 41·3 grains in the water transported by the Colorado River aqueduct.



PLAN OF THE MONO BASIN PROJECT

The Mono Basin project includes means for intercepting and diverting the flow of several of the mountain streams at an elevation of more than 1000ft. above the present surface of the lake, and impounding the water in a regulating reservoir formed within the basin along the course of one of the creeks. From that reservoir, the water will be carried under one of the enveloping mountains and be discharged into an upper branch of the Owens River, and, after following a winding course for about 13 miles, it will flow into a second and much larger reservoir, where the joint waters will be impounded for regulation purposes. When the Mono Basin project is ready for service about the close of this year, it will represent outlays totalling something like $19,000,000.

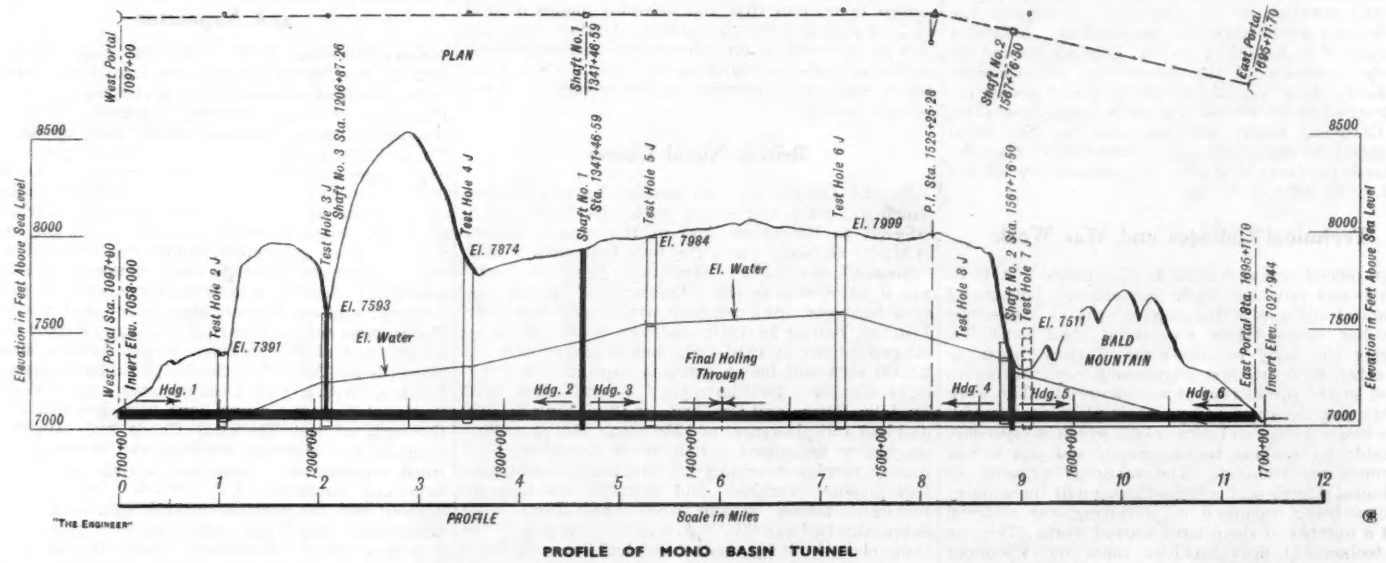
The City of Los Angeles, in 1913, completed and placed in service the Owens River–Los Angeles aqueduct, which has its intake 238 miles north of the city and which obtains much of its water from the snow-capped peaks of the Sierra Nevada Mountains. The aqueduct was designed with a capacity for 480 cusecs of water, but the rate of flow has never exceeded 450 cusecs, and fully 40 per cent. of the water carried comes, not from the Owens River, but from about 100 deep wells in the Owens Valley. The pumping stations are electrically operated by current generated at power plants situated along the aqueduct.

The Mono Basin project embraces the following four principal features: A diversion canal with its heading in LeeVining Creek, which intercepts two tributaries of Rush Creek before discharging into Grant Lake reservoir; Grant Lake reservoir, on Rush Creek, which is intended to regulate the flow of Rush Creek proper as well as the water delivered by the diversion canal; a gravity line from Grant Lake reservoir to the headwaters of the Owens River—the gravity line consisting of conduit, pressure pipe, and tunnels, the longest and most important of which is Mono Craters tunnel; and Long Valley reservoir, outside the basin, and about 13 miles below the outlet of the Mono Craters tunnel. The execution of the project has hinged from the first upon the driving of the Mono Craters tunnel, which has a length between portals of 59,812ft. In its course the tunnel has pierced volcanic formations, and the materials encountered have ranged from extremely hard rock to very freely running sand. Water in large quantities and under high pressure has added to the difficulties and CO_2 in considerable volumes has hampered progress and called for expensive measures to keep the gas under control.

In the Mono Basin, between LeeVining Creek and Grant Lake reservoir, the conduit that diverts water from LeeVining Creek, Walker Creek, and Parker Creek is made up of two tunnels, two sections of pressure pipe, and concrete-lined and covered trapezoidal conduit divisions. The total length of this composite gravity line is 7·2 miles. From LeeVining Creek to Walker Creek the capacity of the aqueduct will be 300 cusecs, increasing to 325 cusecs at the Walker Creek diversion, and continuing with this capacity to Parker Creek, whence it will be 350 cusecs onward to Grant Lake reservoir. Later on, it is planned to extend the conduit system northward of LeeVining Creek to Mill Creek, about 8¼ miles distant, and so obtain an additional mean flow of 21·7 cuses.

Between the Grant Lake reservoir and the northern portal of Mono Craters tunnel, the gravity line, within the Mono Basin, consists of a tunnel 3450ft. long immediately south of Grant Lake reservoir which discharges into a trapezoidal conduit 3 miles long that connects with the Mono Craters tunnel. The conduit sections within the basin are buried a minimum of 2ft., at their tops, beneath earth to prevent freezing. Work on this part of the project has gone forward since the beginning of field construction. The diversion dams at the creeks are of moderate dimensions and are rock and earth-fill structures.

Grant Lake reservoir, on Rush Creek, is to have a capacity of 49,300 acre-feet and will store and smooth out the major fluctuations of the contributing streams. The dam that will create the reservoir is situated in the narrows at the southern end of the site. The structure will rise 72ft. above the original bed of the creek, will be

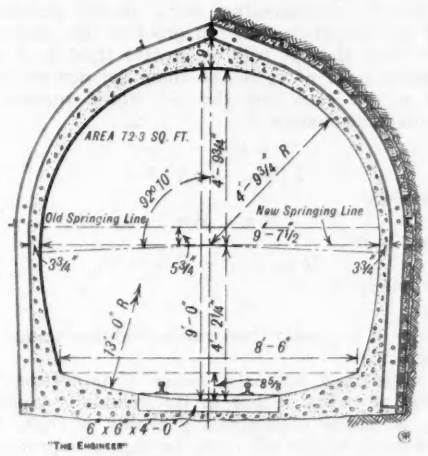


PROFILE OF MONO BASIN TUNNEL

an earth and rock-fill mass, and will rest on a morainal foundation. A road 30ft. wide will occupy the crest, which is about 750ft. long. Work on the Grant Lake dam was discontinued in the autumn of 1936. At that time the stripping of the site had been completed and a total of 366,200 cubic yards of dirt had been removed.

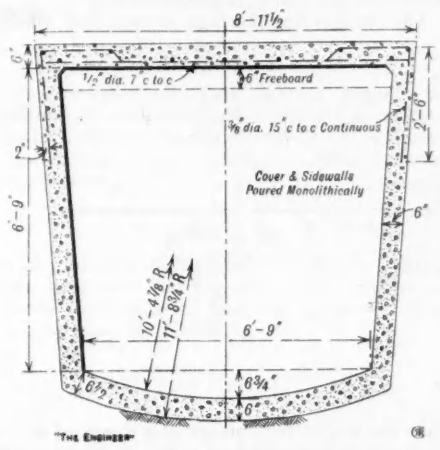
Also at that date 176,310 cubic yards of earth fill had been placed in the main body of the dam, 16,750 cubic yards of rock had been laid on the downstream face, and considerable other work done in connection with the job. Bids are now to be asked for the completion of the dam so that it may be finished before the close of this year. The excavation of the conduit between Grant Lake reservoir and the northern end of the Mono Craters tunnel will be concluded during the first half of this year.

The Mono Craters tunnel was finally holed through on April 26th, 1939, when headings Nos. 3 and 4 met. The driving of the tunnel was started at the west portal, designated as heading No. 1, in September, 1934, and drilling was



SECTION OF MONO CRATERS TUNNEL

commenced at the east portal, heading No. 6, two months later. By sinking shaft No. 2, which was completed in August, 1935, headings Nos. 4 and 5 could be driven. Headings Nos. 5 and 6 met in July, 1936, and thus marked the completion of the 12,735ft. of excavation in the easterly section of the tunnel. The formations penetrated during the driving of this easterly section required timbering for nearly 75 per cent. of the distance. Shaft No. 2 has a depth of 299ft., and its sinking required about four months. Sinking was at an average rate of 6ft. per day, and progress was considerably aided by the use of a deep-well pump that operated within a large perforated pipe, suspended parallel with the shaft but about 11ft. away at one side. Inflowing



SECTION OF TRAPEZOIDAL CONDUIT

water was thus kept under control—a necessary precaution because the ground-water plane at the start of operations was near the top of the shaft.

The original programme of operations called for the sinking of two shafts so that headings could be advanced from four more points within the interior of the projected tunnel. Shaft No. 1 was to be sunk 24,457ft. inward from the west portal, while shaft No. 2 was to be sunk at a shorter distance in from the east portal. Although the sinking of shaft No. 1 was started early in December, 1934, it did not reach tunnel level until about the middle of May, 1937. The sinking of this shaft and the driving of the two headings therefrom, and the driving of heading No. 1 from the west portal presented the greatest difficulties of the entire project. Shaft No. 1 was carried down through volcanic ash and rhyolite for 563ft., and thence downward for 308ft. through an exceedingly troublesome formation made up in the main of unconsolidated glacial material. Despite the nature of the ground from the surface downward, the shaft was sunk and timbered at a fairly satisfactory rate until a depth of 480ft. was reached, at which level water was first encountered. From that elevation water continued to hamper operations in varying degrees. The incoming water, which did not exceed a maximum volume of 5000 gallons per minute, and which was effectually dealt with by an arrangement of pumping chambers and collecting rings, was accompanied by an influx of quicksand. The sand came in with water usually at high pressure and on occasions the water mounted in the shaft by as much as 100ft. in the course of an hour. A single such run raised the level of the water 300ft. above the bottom of the shaft; and when the water was pumped out there remained in the bottom of the shaft a bed of sand 140ft. thick. By the time the shaft reached a depth of 760ft. it had been necessary to clear out 1500 cubic yards of inflowing sand in addition to the volume of material excavated from the shaft itself. The inflowing material was a mixture of sand and gravel. Drainage drifts driven into the sides of the shaft repeatedly failed to function as expected because the water-bearing gravel became sealed with fines that arrested seepage and caused the upbuilding of hydrostatic pressure which later overcame resistance and subjected the shaft to sudden and serious inundation.

In the upper part of the shaft, where the rock penetrated was stable enough to permit timbering, the concrete lining was promptly put in place. Lower down, where the ground was soft, the outlying pressure repeatedly forced the timbering inward. In the upper section of the shaft 8in. by 8in. timbers were used and the sets were placed at 5ft. intervals. Below, in the soft ground, 10in. by 10in. timbers were employed and the sets were arranged at intervals of 4ft. centre to centre. In the still less stable ground intermediate sets had to be employed. Furthermore, as soon as the spiles were driven in advance of the timber sets in the very troublesome ground, grouting was forced into the formation behind the spiling. For this work, a perforated pipe was forced into the outlying ground, through a hole in the spiling, to a depth of 6ft. or so, and the grouting was applied at a pressure of 100 lb. This expedient served well except in the softest of the ground, where the grouting on occasions came back into the bottom of the shaft and brought with it large rocks. At that stage shaft-sinking was suspended for four months, and efforts were centred on exploratory work to ascertain the nature of the ground downward to the tunnel line so as to plan the next method of attack.

The exploratory operations involved sinking a well and disclosed that the tunnel line would be in sandstone. The problem was therefore to continue shaft sinking until that rock was reached. It was decided to rely upon grouting at higher pressure to seal the remaining soft ground that would have to be passed through. Where the outlying ground permitted, drifts were driven from the shaft and excavating was continued around the outside of the timbering; then bulkheads were erected and concrete placed to arrest runs of sand or soft ground. In several instances gravel was placed in the drifts and used as a fill for cavities that had resulted from runs. Grouting, at a pressure of 250 lb., was relied upon to consolidate the ground; and at that stage timber spiles were abandoned and steel sheet piling, in 7ft. lengths, was used instead. In this manner shaft No. 1 was finally advanced until it reached tunnel grade. With the knowledge they have to-day, the responsible engineers would probably proceed differently in dealing with a like problem, but in the case of shaft No. 1 the exact nature of the ground to be dealt with was imperfectly known in advance of sinking.

Shaft No. 1 is lined with reinforced concrete throughout its lower 365ft. The sandstone formation at the bottom of the shaft developed a tendency to "squeeze" because the seams of the rock contained a clay-like material. This fact entailed trouble in holding the somewhat unstable ground. The over-all excavated dimensions of both shafts Nos. 1 and 2 were 7ft. by 20ft. Each shaft was provided with two skipways, each 5ft. by 5ft. 2in., and a combined manway and utility compartment of 5ft. by 6ft. 6in. At the bottom of shaft No. 1 there was sunk below tunnel grade a sump 48ft. deep, and the usual excavations were made outside the tunnel line for station and other purposes. In July, 1937, the driving of headings Nos. 2 and 3 from shaft No. 1 was started.

(To be continued)

The Mathematics of the Balloon Barrage

FOR the purpose of this analysis it will be assumed that the chances in favour of an aeroplane successfully passing through a balloon barrage are proportional to the aggregate width of the unobstructed pathways between the balloons and that the chances of its failing to pass are similarly proportional to the aggregate width of the obstructed pathways. The degree of protection afforded to an area defended by a balloon barrage will be defined as the ratio of the chances of failure to the chances of a successful passage.

In Fig. 1 let W W be the wires of two adjacent balloons in the barrage and let S be the span of the attacking aircraft. For a modern medium bomber S may be taken to be about 50ft. It is evident that at each wire there is an obstructed pathway of width 2 S within which the aeroplane cannot attempt to pass the barrage. The width of this obstructed pathway is the same whether the aeroplane approaches the line W W of the wires normally or in an inclined direction. The width of the unobstructed pathway is, however, materially affected by the angle of approach. If d is the distance between the wires the width of the unobstructed pathway is $d-2\,S$ for normal approach, and $d \sin\theta - 2\,S$ for approach at an angle θ. Since the degree of protection is clearly a minimum for normal approach it will be assumed that in all cases the aeroplane approaches the barrage at right angles to the line joining those two wires between which it seeks to pass.

In the first instance, let us assume that a given area is defended by a single ring of balloons arranged on the periphery of a circle of radius r (Fig. 2), all the balloons flying at the same height. It is evident that whether the balloons are disposed uniformly or non-uniformly round the circle the aggregate width of the obstructed path which they provide is $2\,S\,n$, where n is the number of balloons in the barrage. The aggregate width of the unobstructed path is therefore $2\,\pi\,r - 2\,S\,n$. Hence the degree of protection afforded to the area by the barrage is in accordance with the definition expressed by

$$p_1 = \frac{2\,S\,n}{2\,\pi\,r - 2\,S\,n} = \frac{1}{(\pi\,r/S\,n) - 1}.$$

If the value $\frac{1}{2}$ be assigned to p_1, the implication

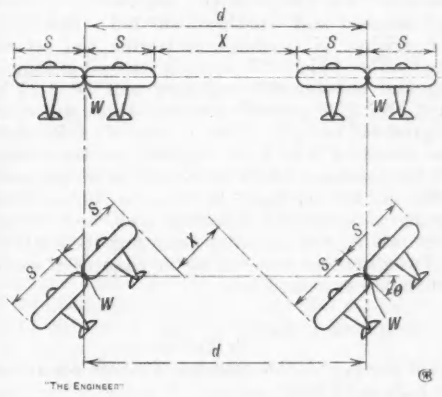


FIG. 1

is that the chances are two to one in favour of an aeroplane penetrating the barrage unscathed, or, in other words, the chances are that two out of three attackers would get through. Taking p_1 at $\frac{1}{2}$ and S at 50ft., we have

$$\pi\,r/50\,n = 3, \text{ or } 2\,\pi\,r/n = 300.$$

But $2\,\pi\,r/n$ is the average distance apart of the balloons. Hence, to secure a degree of protection

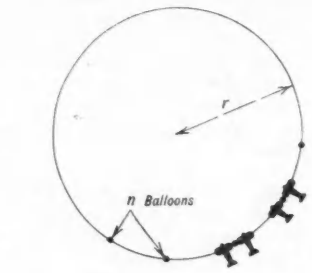
represented by $p_1=\frac{1}{2}$, the balloons would have to be arranged at an average distance of 300ft. apart whatever may be the diameter of the area defended. The number of balloons required would be $n=2\pi r/300$.

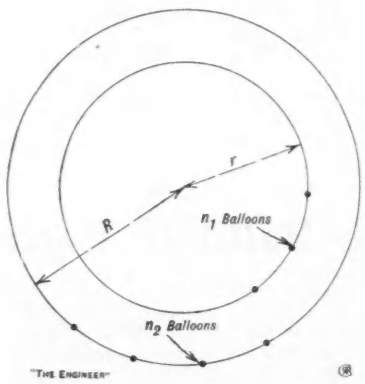
A value of $\frac{1}{4}$ assigned to p_1 implies that on the average four aircraft out of five would succeed in penetrating the barrage. For this value of p_1, taking S at 50ft., as before, we have $2\pi r/n=500$. The balloons would therefore be stationed 500ft. apart, and the number required would be $n=2\pi r/500$, or 60 per cent. of those required to give a degree of protection defined by $p_1=\frac{1}{2}$.

The following table summarises and extends these results. The figures given in the third column are relative only :—

Degree of protection.	Distance apart of balloons, feet.	Relative No. of balloons required.
$\frac{1}{2}$	300	100
$\frac{1}{3}$	500	60
$\frac{1}{5}$	900	33
$\frac{1}{10}$	1700	18

If an aircraft, in addition to penetrating a circular barrage and delivering its attack is subsequently to escape successfully, it must traverse the barrage twice. Let the degree of protection provided be, say, $p_1=\frac{1}{2}$. Then out of three attackers the chances are that two will get through the barrage and one will be brought down. Hence, if N machines make the attack,





FIGS. 2 AND 3

the chances are that $\frac{2}{3}$ N will get through and $\frac{1}{3}$ N will fail to do so. The $\frac{2}{3}$ N machines which succeed in getting through will, after delivering their attack, have to face a second passage of the barrage. On the average, two-thirds of them will succeed and one-third will fail. Hence, of the original N machines delivering the attack, the number which will probably succeed in attacking and subsequently escaping will be $\frac{2}{3}\times\frac{2}{3}$ N, or $\frac{4}{9}$ N. The probable number which will come to grief will be $\frac{5}{9}$ N. The chances of a safe return are therefore 4 to 5, or slightly less than even. Of the machines which fail to return 60 per cent. will, on the average, be brought down while trying to enter the defended area, and 40 per cent. while leaving it after delivering their attack.

For any other value of p_1 the chances of a safe return are expressed by

$$C_1=\frac{1}{p_1\,(p_1+2)}.$$

Thus for $p_1=\frac{1}{16}$ the chances of a safe return are as high as $7\frac{3}{4}$ to 1.

Let us now suppose that n balloons are available for the defence of the area of radius r and that n_1 of them are stationed round its periphery and n_2 of them round an outer circle of radius R (Fig. 3). From Fig. 4 it is obvious that unless we assume some particular disposition of the balloons on the inner ring relatively to those on the outer, we cannot determine the degree of protection afforded to the area by the two rings by a direct calculation of the ratio of the obstructed to the unobstructed pathways. Thus, if the balloons in the two rings are arranged as at A, those of the inner ring will add little or nothing to the protection afforded by the outer ring, whereas if they are arranged as at B the balloons of both rings will contribute to the obstructed pathway. In order to keep the treatment of the problem as general as possible, we must approach it in a slightly different way.

The n_2 balloons in the outer ring considered by themselves provide to the annular area between the rings a degree of protection defined by

$$p_2=\frac{1}{(\pi\,R/S\,n_2)-1},\text{ or, say, }\frac{1}{m}.$$

In other words, the chances are that if $m+1$ machines attempt to pass the outer ring m machines will succeed and one will fail. Hence, if N machines attack the outer ring the probable number which will get through will be $m\,N/(m+1)$ and the probable number which will fail will be $N/(m+1)$.

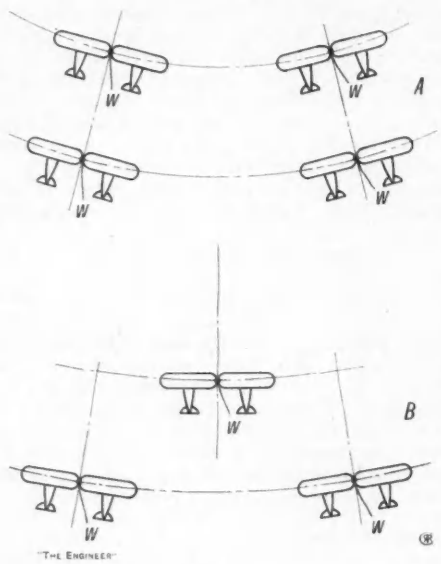


FIG. 4

The n_1 balloons in the inner ring considered by themselves provide to the area within that ring a degree of protection defined by

$$p_3=\frac{1}{(\pi\,r/S\,n_1)-1},\text{ or, say, }1/q,$$

or, in other words, if $q+1$ machines attack the ring the probable number which will succeed in passing it will be q, and one will probably fail. Hence, of the $m\,N/(m+1)$ machines which succeed in passing the outer ring the probable number which will succeed in passing the inner ring will be $m\,q\,N/(m+1)\,(q+1)$, while the probable number which will fail to do so will be $m\,N/(m+1)\,(q+1)$.

Let $p_4=1/u$ be the degree of protection provided to the area within the inner circle by the two rings considered jointly. Then, by definition, if $u+1$ machines attack the joint defences, u machines will probably succeed in penetrating them while one fails to do so. Hence, if N machines attack the defences the probable number which will penetrate them will be $u\,N/(u+1)$. Equating this expression to that previously found we get

$$\frac{m\,q}{(m+1)\,(q+1)}=\frac{u}{u+1},$$

which gives us

$$u=m\,q/(q+m+1).$$

Hence

$$p_4=\frac{1}{u}=\frac{1}{m}+\frac{1}{q}+\frac{1}{m\,q}=p_2+p_3+p_2p_3.$$

By substituting the values of p_2 and p_3 it can readily be established that in terms of R, r, n_1, and n_2, the quantity p_4 has the following value :—

$$p_4=\frac{1}{\dfrac{\pi\,R\,r}{S\,(R\,n_1+r\,n_2)}-1},$$

a formula which is similar in form to those for p_1, p_2, and p_3.

The question now arises whether p_4 can ever be equal to or greater than p_1—that is to say, whether the degree of protection afforded to an area of radius r can be increased by disposing a certain number of the balloons available on an external circle instead of arranging them all on the periphery of the defended area. The answer is that no matter how the n balloons are distributed between the two circles the degree of protection afforded by them will always be less than that given by concentrating them on the periphery of the defended area. In proof of this assertion we note that p_4 will be greater than p_1 if the denominator of p_4 is less than the denominator of p_1, or, cancelling the -1 which appears in both denominators, if

$$\frac{\pi\,R\,r}{S\,(R\,n_1+r\,n_2)}<\frac{\pi\,r}{S\,n},$$

that is, if

$$R\,n<R\,n_1+r\,n_2$$

that is, if

$$R\,(n_1+n_2)<R\,n_1+r\,n_2$$

or finally, if

$$R<r.$$

Since R is greater than r this condition cannot be fulfilled.

Considered not as a means of protecting the area of radius r, but in its secondary capacity as a means of destroying enemy aircraft, the efficiency of the twin-ring barrage is represented graphically in Fig. 5. It will be seen that the probable number of machines which will escape unhurt from the double passage of the twin barrage is a^2N, where $a=m\,q/(m+1)\,(q+1)$. Hence the probable number which will be brought down at one or other of the four crossings is $(1-a^2)\,N$. The chances of a safe return are therefore

$$C_4=a^2/(1-a^2).$$

Substituting for a, m and q it can easily be shown that this ratio reduces to

$$C_4=\frac{1}{p_4\,(p_4+2)}.$$

For the single barrage the corresponding ratio as already found would be

$$C_1=\frac{1}{p_1\,(p_1+2)}.$$

Since p_4, as has been shown, is less than p_1, it follows at once that C_4 is greater than C_1.

The double-ring barrage is thus less efficient

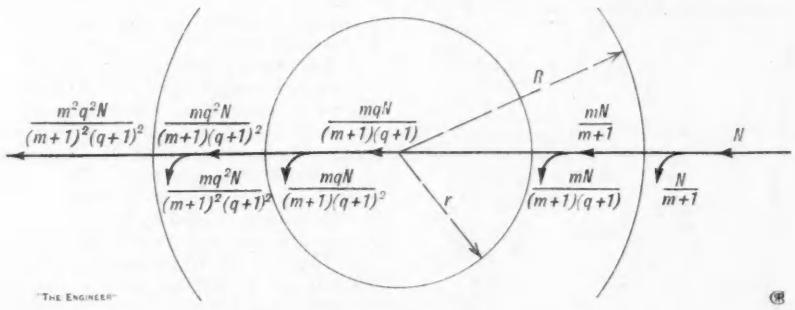


FIG. 5

than the single-ring barrage as a means of defence and also less efficient as a means of preventing the safe return of the attackers.

So far, it should be carefully noted, we have considered the area to be defended as being a circle of radius r and have assumed tacitly that the object aimed at has been to provide a uniform degree of protection over the whole of the circular area. An obviously practicable alternative is to divide the defended area into two zones, an inner and an outer, and to be content with a lesser degree of protection in the outer than in the inner (Fig. 6). It is obvious that the formulæ already developed in connection with Fig. 3 will be applicable to this case if we change R into r and r into ρ. It follows, therefore, that the degree of protection afforded by the twin barrage to the circular area of radius ρ is expressed by

$$p_5=\frac{1}{\dfrac{\pi\,r\,\rho}{S\,(r\,n_1+\rho\,n_2)}-1}.$$

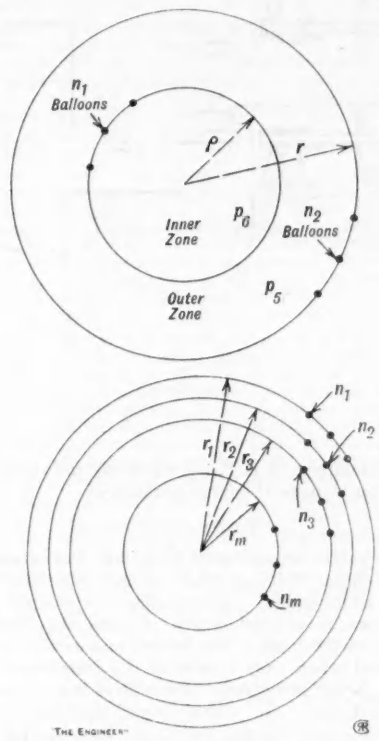
Comparing this with the degree of protection p_1

afforded to the inner zone, conjointly with the outer zone, by stationing all the balloons on the periphery of the outer zone we see, as before, that p_6 will be greater than p_1 if

$$\frac{\pi r \rho}{S(r n_1 + \rho n_2)} < \frac{\pi r}{S n},$$

i.e., if $\rho < r$. This condition is fulfilled, and therefore we can say that in all cases the protection afforded to the inner zone will be greater than it would be if a single barrage with the same total number of balloons were set up round the periphery of the outer zone.

This increased protection of the inner zone is naturally secured at the expense of a decrease



FIGS. 6 AND 7

in the protection given to the outer zone. That protection is expressed by

$$p_5 = \frac{1}{(\pi r / S n_2) - 1}$$

instead of

$$p_1 = \frac{1}{(\pi r / S n) - 1}.$$

A numerical example will serve to indicate the extent of the respective gain and loss of protection. Let the n balloons be distributed on the periphery of the circle of radius r. Then the degree of protection provided is

$$p_1 = \frac{1}{(\pi r / S n) - 1}, \text{ or, say, } 1/k.$$

Let the balloons be redistributed, half remaining where they were and the other half being drawn inwards to a circle of half the radius r. Then $n_1 = n_2$ and $\rho = r/2$. Hence,

$$p_5 = \frac{1}{(2 \pi r / S n) - 1} = \frac{1}{2k + 1},$$

and

$$p_6 = \frac{1}{(2/3 \,.\, \pi r / S n) - 1} = \frac{3}{2k - 1}.$$

For example, if $p_1 = {}^1/_{16}$, then $p_5 = {}^1/_{33}$ and $p_6 = {}^1/_{10 \cdot 33}$. It will be noted that if $p_1 = \frac{1}{2}$, then $p_5 = {}^1/_5$ and $p_6 = 1/1$ implying that the chances of an attacker getting through the inner barrage, are just even. If the n balloons were all stationed on the periphery of the circle of radius r then to give a degree of protection corresponding to $p_1 = 1/1$ they would have to be anchored at an average distance of 200ft. apart—taking S as previously at 50ft. If $p_1 = \frac{1}{2}$, then the average distance apart would be 300ft. Rearranging the balloons in two circles in the specified manner, the outer ring would give as stated a degree of protection $p_5 = {}^1/_5$ to the annular zone and the balloons in this ring would be 600ft. apart. The protection $p_6 = 1/1$ afforded to the inner zone by the twin barrage would be given by anchoring the balloons of the inner ring not at 200ft., but at 600ft. apart—that is, at the same spacing as in the outer ring.

The chances of an attacker making a successful return from the doubly defended area would be expressed by

$$C_6 = \frac{1}{p_6 (p_6 + 2)}.$$

As p_6 is greater than p_1, C_6 would be less than C_1. Hence the rearrangement of the balloons in the manner indicated would not only increase the protection of the inner zone, but would also decrease the chances of an attacker returning home successfully.

The treatment may be extended to cover the defence of an area of radius r_1 by means of a series of m rings of balloons arranged inside the ring of radius r_1 (Fig. 7). The problem is to discover the degree of protection afforded to the area within the inside circle of radius r_m.

The protection afforded by the n_1 balloons on the circle of radius r_1 is expressed by

$$p_1 = \frac{1}{(\pi r_1 / S n_1) - 1} = \frac{1}{q_1}.$$

Hence, out of N aircraft attacking this barrier, the probable number which will succeed in crossing it will be $q_1 N/(q_1+1)$. The protection afforded by the n_2 balloons in the circle of radius r_2 considered by itself is expressed by

$$p_2 = \frac{1}{(\pi r_2 / S n_2) - 1} = \frac{1}{q_2}.$$

Hence, of the $q_1 N/(q_1+1)$ aircraft which succeed in penetrating the first barrage the probable number which will succeed in penetrating the second barrage will be $q_1 q_2 N/(q_1+1)(q_2+1)$. And so on for the succeeding rings. Hence the probable number which will succeed in penetrating the inmost ring of radius r_m will be

$$(q_1 q_2 q_3 \ldots q_m)\, N/(q_1+1)(q_2+1) \ldots (q_m+1).$$

If p_a is the actual protection afforded to the inmost area by all the rings taken together and if p_a has the value $1/u$, then, by definition, out of N machines approaching the barrage, $u N/(u+1)$ should succeed in reaching the inmost area. Hence

$$\frac{u}{u+1} = \frac{q_1 q_2 q_3 \ldots q_m}{(q_1+1)(q_2+1) \ldots (q_m+1)}.$$

This expression gives us

$$p_a = \frac{1}{u} = a - 1,$$

where

$$a = \frac{(q_1+1)(q_2+1) \ldots (q_m+1)}{q_1 q_2 q_3 \ldots q_m}$$
$$= (1 + 1/q_1)(1 + 1/q_2) \ldots (1 + 1/q_m)$$
$$= (1 + p_1)(1 + p_2) \ldots (1 + p_m)$$

Hence

$$p_a = p_1 + p_2 + \ldots p_m$$
$$+ p_1 p_2 + p_1 p_3 + \ldots p_2 p_3 \ldots$$
$$+ p_1 p_2 p_3 + \ldots p_2 p_3 p_4 \ldots$$
$$+ p_1 p_2 p_3 p_4 + \ldots$$
$$+ \ldots$$
$$+ p_1 p_2 p_3 \ldots p_m$$

Let it be assumed that $p_1, p_2, p_3 \ldots p_m$ are all equal, say, equal to p. This condition will be fulfilled if $r_1/n_1 = r_2/n_2 = \ldots r_m/n_m$—that is to say if the number of balloons on any circle is proportional to the radius of the circle. Then we have

$$p_a = m\,p + \frac{m(m-1)}{2} p^2 + \frac{m(m-1)(m-2)}{6} p^3 + \ldots + p^m = (1+p)^m - 1$$

As a numerical example, let $p = {}^1/_{16}$ and assume that we desire to provide the inner area of radius r_m with a degree of protection defined by $p_a = 1/1$. Then $(1+p)^m = 2$, or

$$m = \frac{\log 2}{\log 17 - \log 16} \doteqdot 11\tfrac{1}{2}.$$

Hence, twelve rings of balloons each giving by itself a degree of protection $p = {}^1/_{16}$ would give, taken together, a 1 to 1 degree of protection to the innermost ring. A degree of protection of 1 to 1 implies that the chances in favour of an attacker escaping after delivering its attack are 1 to 3—that is to say, out of four machines engaged in the attack three would probably be brought down either while entering or escaping from the barrage.

Natural Gas Engine for Trinidad

By G. W. A. TOOKEY, M. Inst. C.E., M.I. Mech E.

No. I

A LITTLE more than a year ago—December, 1938—successful acceptance trials were made in Trinidad of a Crossley-Premier gas engine with direct-coupled Metrovick alternator, which besides being the largest British-made set in the world operating on natural gas presents many novel features of general interest.

The set consists of the standard Crossley-Premier horizontal construction, the twelve cylinders being arranged in four groups of three. Two of these groups are placed *vis-a-vis* fashion on each side of a centrally disposed flywheel, to the arms of which the rotating field of the alternator is bracketed. The general arrangement of the set can be appreciated from the illustration, Fig. 3 on page 554, which is a reproduction of a photograph taken whilst the set was undergoing shop trials before shipment to Trinidad. On site—see Fig. 5 on the same page—it operates in parallel with three Crossley heavy-oil engine sets running at 375 r.p.m. and rated at 280 kW. The current generated is used for general service on one of the major oil producing fields on the Island, including the transfer of oil from the wells to the refinery 20 miles away.

Alternator

The alternator was built by Metropolitan Vickers Electrical Company, Ltd., at Trafford Park, Manchester, and is rated at 1000 kW, at 0·77 power factor, 1300 kVA., 2300 volts, three-phase, 60 cycles per second when running at 212 r.p.m., and in conjunction with a closed air circuit cooler. As will be seen from the general arrangement drawing (Fig. 2) the exciter armature is overhung on an extension of the engine crankshaft. Six thermo-couples are provided in the stator winding and core in connection with interconnecting leads to a remote indicator so that the temperature during operation can be noted.

In view of the humid conditions prevailing on site, the alternator is provided with heaters to prevent condensation of moisture on the windings. Being arranged for closed air circuit ventilation the heaters when in use ensure that no entry of moist external air takes place when the set is at rest. The guaranteed efficiencies were as follows :

Output at 0·85 power factor, kW. ...	1000 ...	750 ...	500
Efficiency, per cent.	93·9 ...	93·5 ...	92·0

The guaranteed rise in voltage from full load to no load with constant speed and excitation was at unity power factor 15 per cent.; at 0·85 power factor 30 per cent. The generator reactance was given as approximately 20 per cent.

Air Cooler Equipment for Alternator

The cooler equipment consists of a rectangular nest of solid drawn brass tubes with copper wire loop coils wrapped spirally around the outer surface with a binding wire wound tightly inside the loops, and the whole sweated to the tubes at point of contact. The air flow is over the gilled loops and the water passes through the tubes which terminate at each end in a cast iron water chamber. Sheet steel air ducting is provided to connect the generator yoke air outlet to the cooler inlet. Hand-operated dampers are provided for shutting off the air cooler and opening the alternator to the atmosphere when desired.

In order to give warning of an abnormal temperature of the air at the inlet of the generator, an alarm device is incorporated consisting of a Klaxon horn electrically operated, by means of a dial thermometer having suitably arranged insulated contacts, through a relay. Current for this alarm is independently available and the alarm apparatus is mounted on a planished steel panel—black and nickel finished—and includes a re-set push button, a red lamp, glowing when the horn is operated and a mechanically operated indicator showing the position of the dampers.

The engine foundation is specially designed for

the passage of the air ducting below ground. The arrangement of the cooler is shown in Fig. 2. A portion of the engine general arrangement and piping is also shown.

ENGINE CONSTRUCTION

The engine bed forms the central section of each group, on each side of which are bolted the water jacket casings, each surrounding three power cylinders. At the base of the bed a channel is cast to prevent oil leaking to the concrete foundation. The four bearing shells, for the three-throw crank of large diameter, to which the six cylinders are connected, are of cast iron and lined with white metal, shims being provided for ready adjustment of wear. The flywheel and alternator are carried on a centre shaft between the two six-cylinder groups. Generally, the construction is in accordance with the well-tried practice of Crossley-Premier engines known the world over, but there has been a departure of particular interest in the design of the pistons, for they are arranged for internal air cooling as an addition to the standard practice, embodying a split skirt and separate crown. Two large studs are provided which hold the piston pin in place and through these studs air respectively enters and leaves from the piston crown, on the underside of which ribs are cast to increase the heat extraction. Fig. 1 indicates the salient features of this novel method of piston cooling.

The makers claim that piston cooling by air has many advantages when compared with the use of liquids—water or oil—and it has proved to be quite efficacious in practice. It was adopted after special preliminary trials had successfully demonstrated its possibilities. In one of these experiments a furnace was erected round the crown of the piston and in the piston itself a series of thermo-couples was arranged at selected points so that definite readings could be made and recorded. The skirt of the piston was exposed to atmospheric air and the amount of heat supplied to the furnace around the piston crown was just sufficient to keep the latter at red heat when uncooled. The furnace temperature was first brought to slightly over 600 deg. Cent. and throughout a period of 100 minutes the temperatures of the various points of the crown and skirt were recorded and had become stabilised. The test was then repeated at varying cooling air pressures and the temperatures were again recorded from the pyrometer readings over the same time period. The results indicated that the temperatures at the piston crown could in this way be reduced by about 150 deg. Cent.

The acceptance tests at Trinidad confirmed these experimental results and as will be seen from figures tabulated in the second part of this article about 1·1 per cent. of the total heat in the fuel gas supplied to the engine was carried away by this means of cooling. Even at 1750 B.H.P. output (15 per cent. overload) no signs of pre-ignition were noticeable either audibly or disclosed by the indicator diagrams during the hour's run.

The air required for cooling the piston was provided by a motor driven fan absorbing approximately 10 H.P.—a relatively unimportant addition to normal engine resistances.

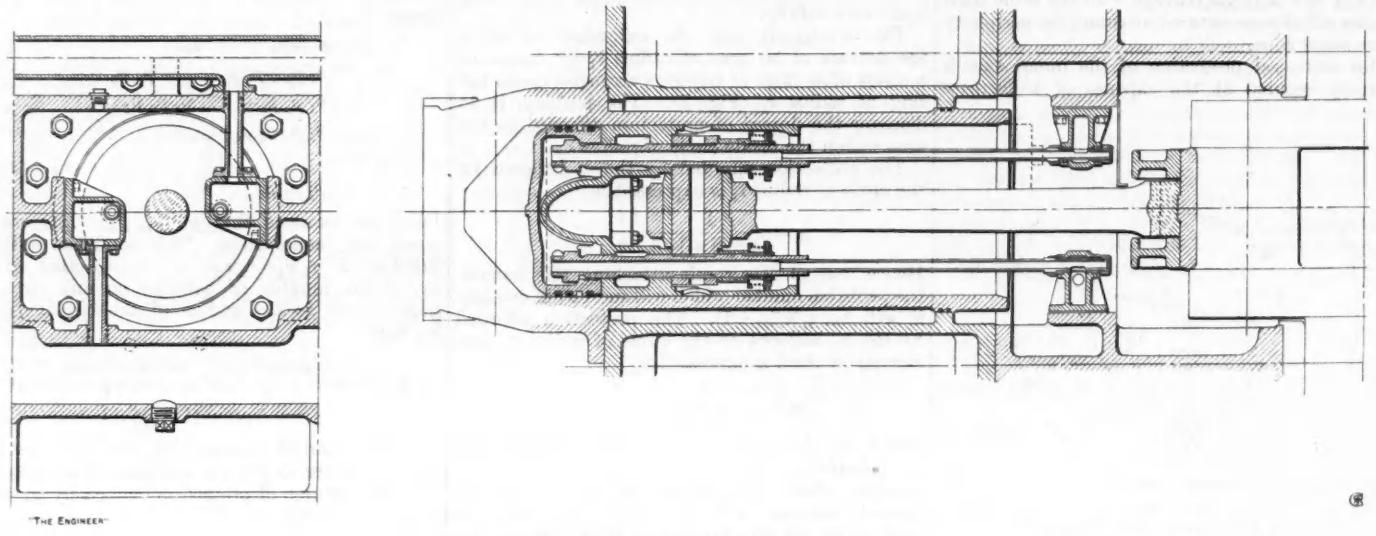


FIG. 1—ARRANGEMENT FOR AIR COOLING OF PISTON

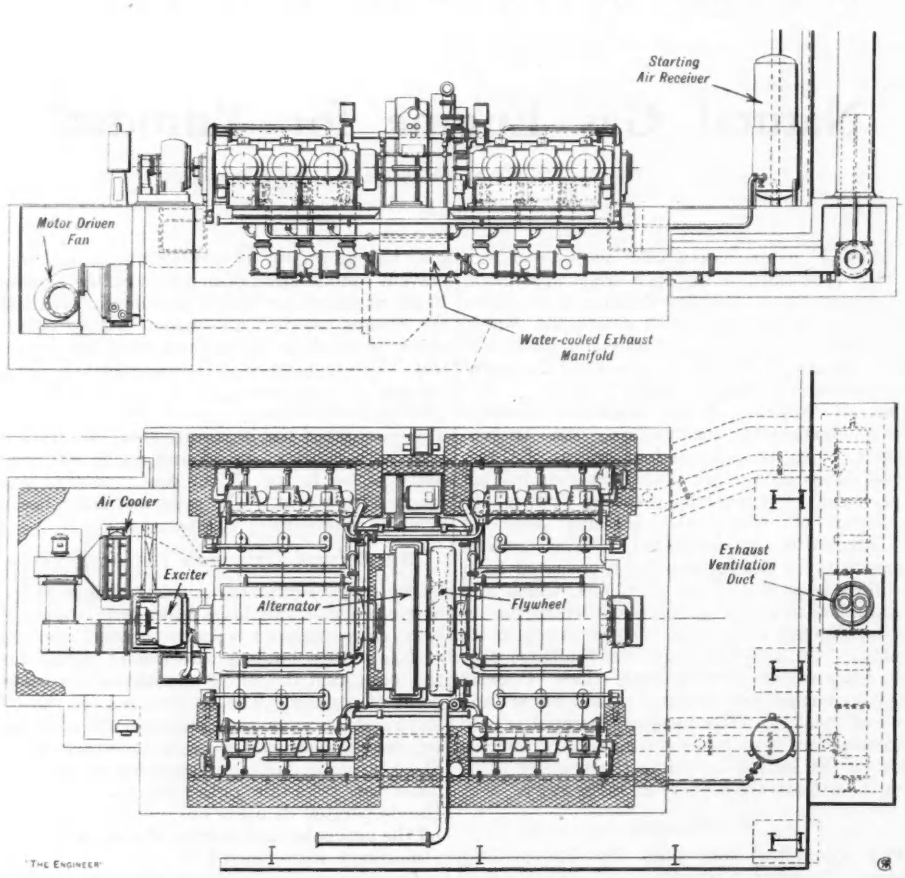


FIG. 2—GENERAL ARRANGEMENT OF 1000-kW GAS ENGINE ALTERNATOR SET

VALVE GEAR

The valves are operated by a cam shaft running in self-oiling bearings made in halves in cast iron with white metal linings disposed behind the cylinders at a level which permits the circular plates on the back of the breech end casting to be removed when easy access to the interior of the water jacket is desired. The valves are vertically disposed and the valve cage, containing the admission and the gas valve, can be removed and replaced quickly as it is fitted to the top of the cylinder with a ground metal-to-metal joint. Through this aperture the interior of the combustion chamber can be inspected. The exhaust valve being directly under the admission valve can be withdrawn through the same opening. The exhaust valves, spindles and guides are both internally water-cooled.

Contrary to usual practice the fulcrum pins of both admission and exhaust valve levers are secured in the levers and oscillate in fixed bearings, which being wide apart minimise the effect of wear, usually evidenced in course of time by side-rocking. The larger area of contact thus provided lessens the effect of the pressure due to valve operation, and in the case of the exhaust valve lever the pressure is taken on the base of the bearings where a supply of lubricating oil is always preventing metal-to-metal contact.

(To be continued)

CAST IRON DIES.—In an article on dies of cast iron in the *Iron Age*, Mr. Richard Bredenbeck points out that the production and ready availability of high-tensile irons and the successful application of flame hardening to them has made it possible and practical to build drawing and forming dies of nothing else but high-tensile iron. The design of the part to be drawn or formed is an important factor in the planning of such dies, and it is not considered advisable to use them where there is a scraping effect of a blanked sheet edge on the die walls in the operation of the tool.

DESIGNS FOR SMALL HUTS.—A War-time Building Bulletin, which has just been issued by the Building Research Station of the Department of Scientific and Industrial Research, deals with the hut type of building, for which a big demand has arisen as a result of the war. Certain requirements are demanded by planning, loads and working stresses, conditions of comfort, such as heat insulation and rain penetration, and the availability of materials and labour. They are discussed in the first part of the Bulletin, and two tables are given, the first of which shows the estimated heat loss per hour for varying types of floors, walls and roofs, while the second shows the comparative total heat loss for huts erected from combinations of these components. Various types of construction for walls, floors, and roofs are then discussed, mainly with the idea of eliminating steel and timber to as great an extent as possible. Tables are given to show the advantages and difficulties of these different constructions. Drawings are given for nine different kinds of roof construction using asbestos cement, hollow tiles, *in situ* and pre-cast reinforced concrete, &c.

Rail and Road

ROAD ACCIDENT FATALITIES.—The return of the Ministry of Transport of the number of persons reported to have died during the month of May as a result of road accidents totalled 449 as compared with 553 for the corresponding period last year.

ROAD CONTROL ARRANGEMENTS.—It is officially announced that the Royal Automobile Club, and the Automobile Association have placed at the disposal of the Government defence forces all arrangements for the control of roads and road traffic.

RENEWAL OF MOTOR VEHICLE LICENCES.—The Minister of Transport has appealed to motorists to make early application for the renewal of motor vehicle licences which expire at the end of June in order to avoid congestion in local taxation offices caused by late applications. Applications for such licences may be made as from June 17th.

RAILWAYS AND WAR DAMAGE.—Lengthy discussions between the railway companies of this country have resulted in the agreement in principle of a plan for the pooling of losses resulting from war damage. It was previously agreed that the first ten million pounds a year of any war damage is to be charged as joint expenditure out of the gross receipts of the Railway Pool. Details of the new scheme remain to be worked out.

SPECIFICATION FOR TROLLEY LINE EQUIPMENT.—A joint committee representing the Municipal Passenger Transport Association and the Public Service Transport Association has issued a revised specification for overhead equipment, collector wire, and accessory fittings. In this revision only performance and essential requirements have been specified, detailed design having been left to manufacturers in conjunction with operators to comply with local conditions.

TROLLEYBUSES IN LONDON.—The scheme which the London Passenger Transport Board had in hand at the beginning of the war for the change over from trams to trolleybuses has now been completed with the change over of two routes in the East End. No further conversion is likely till after the war has ended, and there are now 1671 trolleybuses in service on 256 route miles in London. The only trams now running north of the Thames are those on the Embankment and Kingsway Subway services.

AN OLD AMERICAN FERRY BEING REPLACED BY A BRIDGE.—What is said to be the oldest ferry in the United States, across the western passage of Narragansett Bay, which dates back to 1675, is being replaced by a toll bridge at a cost of 3 million dollars. The entire structure is 6982ft. long, and includes six deck truss spans, each 270ft. long, and two 256ft. long anchor spans flanking a 640ft. cantilever span. The bridge will carry a 22ft. wide road and a 3ft. footpath. Its clearance above mean high water will be 135ft.

MOINTY-CHU RAILWAY.—Survey work has been commenced on the route of the projected Mointy-Chu Railway, which will be 267 miles long. It is the last section of the Trans-Kazakhstan line connecting Petropavlovsk-Akmolinsk-Karaganda-Balkhash, built during the Five-Year Plans. With the construction of the new Mointy-Chu section, this trunk line will acquire an outlet to the Turkestan-Siberian Railway. The new line will shorten the route by more than 620 miles, over which coal has to be carried from Karaganda to South Kazakhstan.

A NEW FORM OF ROAD KERB.—An interesting type of white-faced concrete kerb which reflects light and is distinctly visible to night drivers in both wet and dry weather has been developed in New Jersey. It consists of a sloping concrete kerb faced with about 1in. of white mortar, the surface of which is scored to form saw-tooth-shaped serrations, the vertical faces of which face towards the oncoming traffic. In principle the surface as a whole consists of a series of small reflecting surfaces which lie approximately perpendicular to the headlight rays.

THE CHICHESTER BY-PASS.—The recently completed by-pass road at Chichester has been opened to traffic. This road is nearly 4 miles long and its width of 100ft. was intended to accommodate double carriageways, cycle tracks, and footpaths. The outbreak of war caused the abandonment of the second carriageway after the completion of 1 mile of its length; the cycle tracks and footpaths are only provided at junctions. Owing to the modification the original estimated cost of £203,500 was reduced by about £93,500. Its construction has involved the building of bridges over the Southern Railway, the Chichester Canal, the River Lavant, and two subways for access to some gravel pits.

NEW SOVIET LOCOMOTIVES.—It is reported from Voroshilovgrad (Ukraine) that the "October Revolution" Works has built a new locomotive, of the "F D" type, using coal dust as fuel. The locomotive is now being tested on the Krasny Liman-Sentyanovka Railway. A coal-crushing unit is installed on the tender. Coal of low quality is used. During the tests the locomotive is said to have hauled a train weighing 1650 tons. The same works has also built the first "S O" locomotive with tender condenser, which is said to be capable of running for more than 620 miles without having to take on water. In the first test runs on the railway section Voroshilovgrad-Chebotovka, the condensing plant functioned satisfactorily.

THE MEASUREMENT OF RAIL MOVEMENT.—In the *Journal* of the Royal Technical College, Glasgow, Mr. J. W. Atwell describes an electrical device for measuring the vertical acceleration of the end of a rail and of a sleeper on railway lines. The principle involved was previously employed by Dr. H. H. Davis in the measurement of vertical accelerations of a moving wheel, and the research was part of a major investigation into rail joint deterioration. The device consists of a pressure detector of the carbon granule type, whose electrical resistance is proportional to the mechanical pressure applied, which forms one arm of a balanced Wheatstone bridge circuit. Change of mechanical load disturbs the balance of the bridge, the resulting variation of potential difference being amplified electrically and reproduced on the screen of a cathode ray oscilloscope in conjunction with a moving film camera for recording the voltage changes.

Miscellanea

A FANS EXPORT GROUP.—Under the chairmanship of Mr. W. A. Davidson a Fans and Ancillary Equipment Export Group has been formed. The Secretary of the Group is Mr. A. G. Marshall and the offices are at 2, Howard Street, Strand, London, W.C.2.

THE LONDON CHAMBER OF COMMERCE (INCORPORATED).—At the meeting of the Council of the London Chamber of Commerce, Mr. Henry Morgan was re-elected Chairman, Lieut.-Colonel G. R. Harding was elected as Deputy Chairman, and Mr. J. McLean as Treasurer.

TIMBER CONTROL BOARD.—A Timber Control Board, under the chairmanship of Mr. G. Dallas, has been set up by the Minister of Supply. Other members of the Board are Major A. L. Harris and Sir Roy Robinson. It is understood that the Mines Department will be represented on the Board for the consideration of questions relating to mine timber.

A LARGE EXCAVATOR.—A report from the U.S.S.R. states that there is at present under construction at the Kramatorsk works an excavator capable of handling up to 19,070 cubic feet of earth per hour. It will be driven by twenty-five engines—the power of which is not specified—and its equipment includes five generators. The dragline is said to extend 164ft.

MAGNETIC TESTING FOR NON-FERROUS ALLOYS.—It is reported that an extension of the method employed for testing iron and steel components by the "Magnaflux" system, in which a field is created in the component and a fluid poured over it containing small iron particles, has been developed in the shops of the Transcontinental and Western Air Company. By employing a special technique developed by the company it has been found possible to detect by this method cracks in bronze and in duralumin.

BRITISH WATERWORKS ASSOCIATION MEETING.—It has been decided that the twenty-ninth annual general meeting and conference of the British Waterworks Association will not be held at Sheffield as previously contemplated, but that the meeting will take place at the Association's offices, Grand Buildings, Trafalgar Square, London, W.C.2, on Wednesday, June 26th instant, at 2.30 p.m. The proposed visit to the works of the Derwent Valley Water Board and other functions arranged have been abandoned.

MINISTRY OF SUPPLY APPOINTMENT.—Mr. J. Davidson Pratt has been appointed an additional Deputy Director-General for Chemical Research, Experiment and Development in the Ministry of Supply. Mr. Davidson Pratt has been connected with research and development in chemical defence for the War office since 1916. He largely relinquished this work in 1928 on being appointed General Manager of the Association of British Chemical Manufacturers. That Association has now agreed to second him for his present appointment.

TEACHERS AND ARMAMENT PRODUCTION.—A memorandum issued by the Board of Education urges local education authorities to facilitate the release of handicraft teachers and teachers of woodwork who might be able to give useful service in armament production. The Board also points out that lathes and other metal-working machine tools available in some elementary and secondary schools might be used for the production of small parts for local firms. Teachers solely employed on production will be paid the appropriate trade rates subject to their receiving, for forty-eight hours' work in the week, not less than their normal full-time salary; for any additional hours over forty-eight they will receive overtime at industrial rates.

POWER TRANSMISSION EXPORT GROUP.—The formation of an export group for the power transmission industry is now being arranged. Mr. A. Croft, managing director of Crofts (Engineers), Ltd., Thornbury, Bradford, has been asked by the Export Council to take the initiative in the forming of this group, and has already communicated with most firms convening a meeting for June 24th at the North-Eastern Station Hotel, York, commencing 2.30 p.m. This meeting will deal with the election of group representatives, appointment of chairman and secretary, and also give an opportunity to member firms to express their views. All firms interested should communicate in the first instance with Mr. A. Croft, care of Crofts (Engineers), Ltd., Thornbury, Bradford.

BORAX FOR FIRE-RETARDING PAINTS.—The United States Forest Products Laboratory has found that the most satisfactory materials for fire-retarding paints are linseed oil paints containing finely ground borax. These paints are not recommended for exterior use but inside buildings. Whilst they will not protect wood effectively against continuous exposure to high temperatures, they afford considerable resistance to the spread of small fires. Best results have been obtained with paints pigmented with white lead, but titanium and zinc sulphide pigments have also been found effective. A typical formula of a fire-retarding paint is as follows, the figures being percentages by weight:—White lead, 41·0; borax, 32·0; raw linseed oil, 22·8; turpentine, 3·6; Japan drier, 0·6.

CALCIUM CHLORIDE FOR AIR CONDITIONING.—An abstract from an American journal in the *Chemical Trade Journal and Chemical Engineer* says that Mr. C. R. Downs has recently found that by pouring molten calcium chloride of about 72 per cent. $CaCl_2$ into a suitable type of travelling mould, he could produce uniform non-porous lumps. While the chloride is in the molten state, wetted activated carbon can be dispersed in it to impart the additional property of odour adsorption. This material is the patented absorbent "Caloride." Equipment has been developed for applying this material to the dehydration of air in both residential and industrial air conditioning. The industrial type uses calcium chloride solution, reconcentrated as it becomes diluted in use. With the regenerative cycle, dehydration is performed in an air-liquid contactor, where the air, saturated with solution, passes through cooling oils, is separated by spray eliminators, and emerges at a predetermined lower humidity. About one-sixth of the solution is continuously withdrawn from the sump to the concentrator, where it is regenerated with low-pressure steam and air.

Air and Water

CONCRETE BARGES.—An order is reported to have been placed by the Admiralty for a number of experimental concrete barges.

MINISTRY OF AIRCRAFT PRODUCTION APPOINTMENT.—The Ministry of Aircraft Production announces that Mr. Morris W. Wilson, President of the Royal Bank of Canada, has been appointed the Agent of the Ministry in the United States and in Canada.

AMERICAN HONOUR FOR SIR STEPHEN PIGOTT.—The Gold Medal and certificate of the American Society of Mechanical Engineers has been awarded to Sir Stephen J. Pigott, managing director of John Brown and Co., Ltd., by the American Consul-General in Glasgow.

GERMAN BATTLESHIPS DAMAGED.—An Admiralty communiqué recently stated that the German 25,000-ton battleship "Scharnhorst" has been seriously damaged by a bomb dropped by aircraft of the Fleet Air Arm. This vessel was damaged early in April during a running fight with H.M.S. "Renown."

LOSS OF THE "ROTHESAY CASTLE."—The Ministry of Shipping tribunal appointed to inquire into the stranding and loss of the 7016-ton motorship "Rothesay Castle" on January 4th off the West Coast of Scotland, found that the cause was the serious default of the master, who failed, in its opinion, to exercise ordinary and reasonable care in navigation of the vessel.

MERCHANT SHIPPING LOSSES.—During the week ended Sunday, June 9th, nine British ships, totalling 41,536 tons; two allied ships, totalling 952 tons; and two neutral ships, totalling 4472 tons, were lost as a result of enemy action. German mercantile losses up to June 16th amounted to about 837,000 tons, and Italy's losses up to the same date, since her entry into the war at midnight, June 10–11th, already totalled some 230,000 tons.

PORT ORGANISATION IN GREAT BRITAIN.—In connection with the Port Emergency Committees, which have been set up at each of the principal commercial ports in this country to secure effective operation, the Minister of Transport has arranged for Mr. Frank Pick, lately Vice-Chairman of the London Passenger Transport Board, to visit certain ports in the United Kingdom and to report to him on the organisation that has been set up to secure the speedy discharge and clearance of goods, so as to ensure that any exceptional demands likely to be made on the ports will be met.

AN AMERICAN TURBO-ELECTRIC TANKER.—It is reported that the General Electric Company, Schenectady, is to construct the propelling machinery for a 19,405-ton all-welded turbo-electric tanker. The contract includes the turbines and the electric drive, the latter being designed to develop 5000 H.P. to give the vessel a speed of 13¼ knots. Capacity will be the equivalent of 6,552,000 gallons. Delivery is to be made in the summer of 1941. The machinery is for a vessel which the Sun Shipbuilding and Dry Dock Company is building at its yard at Chester, Pa., for the Atlantic Refining Company, Philadelphia.

LLOYD'S REGISTER OF SHIPPING.—At a recent meeting of the Glasgow Committee of Lloyd's Register of Shipping, Mr. J. Shearer and Mr. D. S. Philp were re-elected Chairman and Deputy Chairman respectively. Four members of the Committee came up for re-election and were appointed: Messrs. N. P. Donaldson, Ion R. Harrison, Henry Main, and James Shearer. Eight members were re-elected to serve on the General Committee in London. These were Mr. John R. Campbell, Mr. W. L. Denholm, Sir Thomas Dunlop, Bt., Mr. Ion R. Harrison, Mr. John Hay, Mr. George Jackson, the Hon. John S. Maclay, and Mr. D. S. Philp.

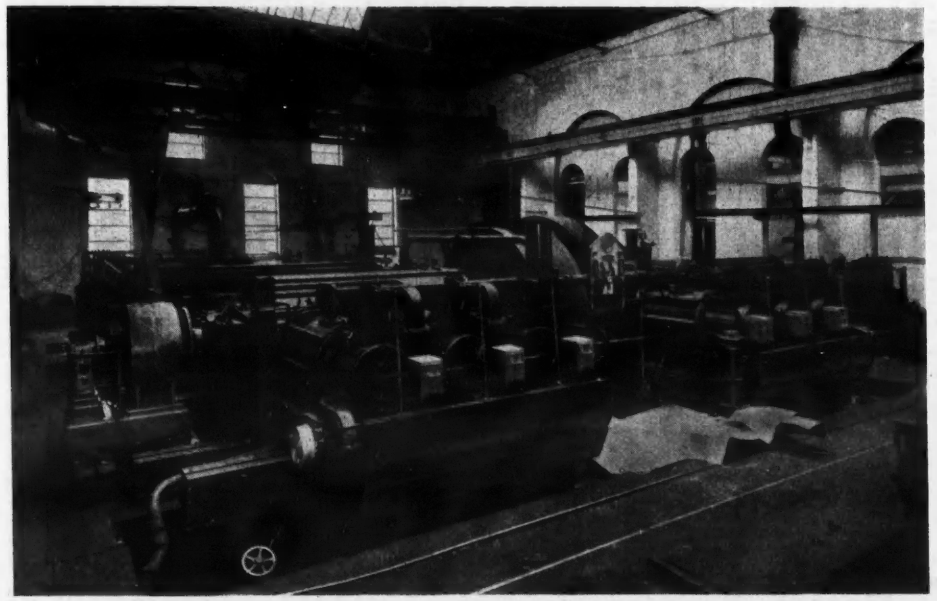
LARGE SOVIET PASSENGER AIR LINER.—A new Soviet passenger air liner, "L-760," was recently put into regular service on the Moscow-Mineralniye Vody (Caucasus) air route. The test flight the machine previously carried out over this route, which is 965 miles long, took 7 h. 42 min., with landings at Rostov-on-Don and Kharkov. The "L-760" has a flying weight of 46 tons, seating accommodation for sixty-four passengers, and carries a crew of ten. The machine has a wing span of 210ft., and its six engines have a power output of 8000 H.P. The machine can carry sufficient fuel for a non-stop flight of 1864 miles. It has a ceiling of 23,000ft. and a maximum speed of 186 m.p.h.

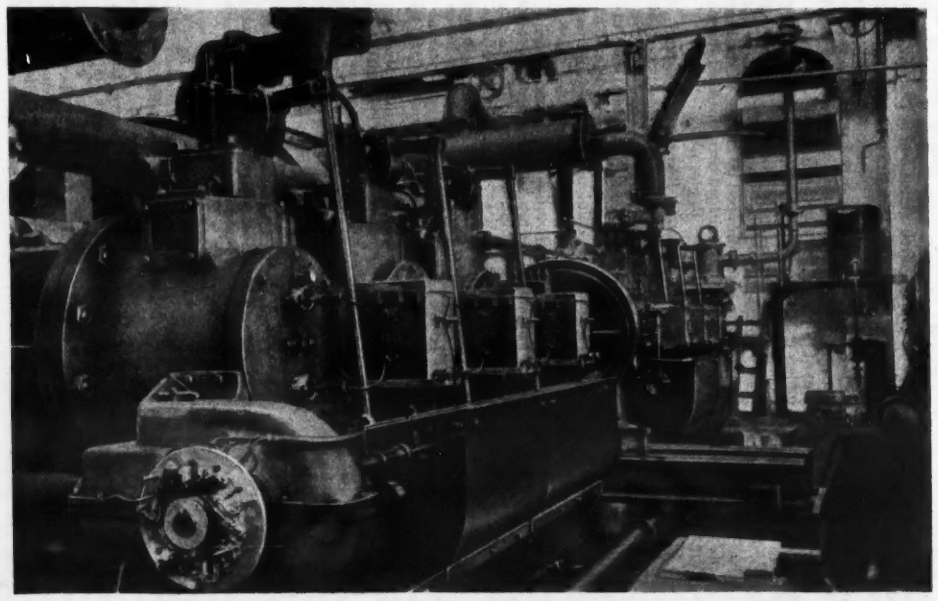
AMERICAN AIRCRAFT PRODUCTION.—In a short note in our issue of May 24th we gave brief particulars of a report by Major-General Arnold on the productive capacity of the United States aircraft industry. In a later official testimony he amplified his previous statement, in which he said that the country's absolute productive capacity would probably be, by using 2½ shifts, somewhere between 24,000 and 30,000 machines annually. He then emphasised that this was the absolute maximum capacity based upon expanded production of all types of machines, *i.e.*, low-powered sports models as well as commercial and purely military types, and was dependent upon the securing of properly qualified mechanics, administrative personnel, and engineers. He considered that the problem of obtaining qualified personnel was so difficult that the maximum capacity of the industry could not be reached for at least one year.

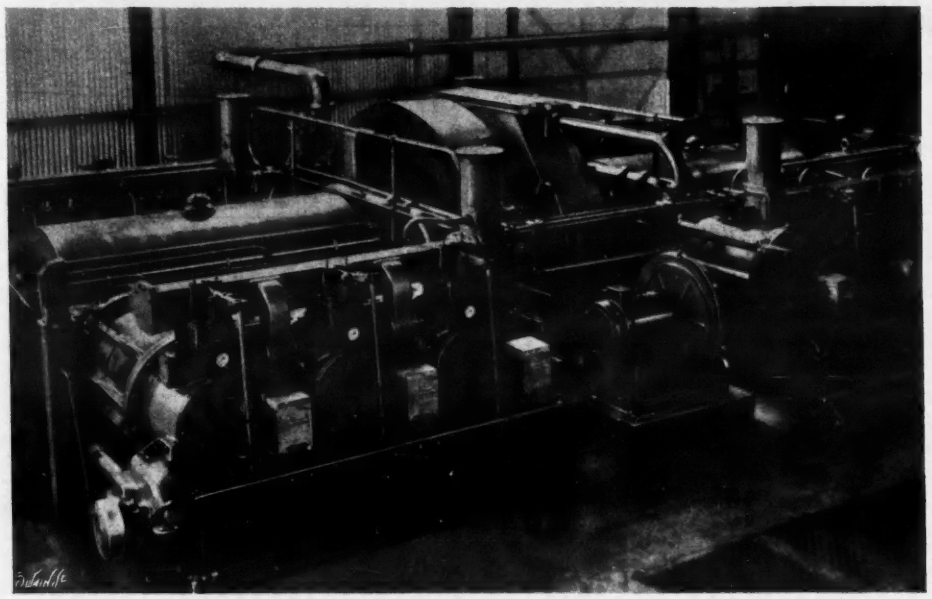
TROOP-CARRYING AIRCRAFT.—Some particulars of the troop-carrying aircraft employed by the German army were recently given by Captain Balfour in the House of Commons. A Member had asked for information about the nature and calibre of the armament, other than small arms, carried by German troop carriers and similar aircraft which have been employed in the operations on the Continent. Captain Balfour said that in addition to the usual small arms, the troops carried are known to have been equipped with heavy machine guns of 13 mm. and 20 mm. calibre, with 5 cm. and 8·1 cm. mortars, with 7·5 cm. infantry guns, and possibly 10·5 cm. light howitzers. The most widely used German troop carrier is the three-engined Junkers 52, which is capable of carrying about fourteen troops, has a maximum speed of 190 m.p.h., and a range of 1000 miles. The more modern Ju. 90 carries nearly three times as many troops and has a top speed of 225 m.p.h.

NATURAL GAS ENGINE FOR TRINIDAD

(*For description see page 551*)







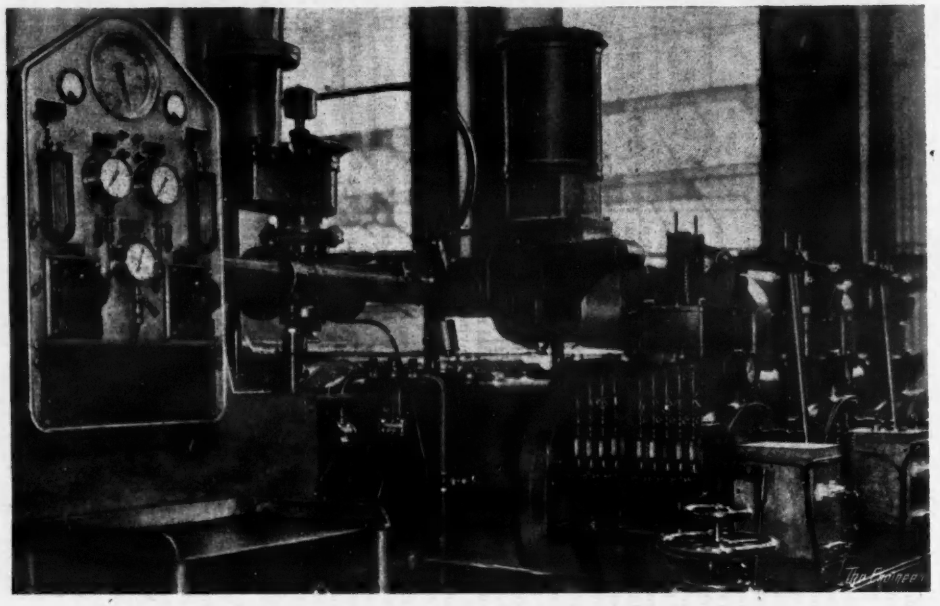


FIG. 3—ENGINE AND ALTERNATOR IN TEST BAY

FIG. 4—END VIEW SHOWING IGNITION GEAR

FIG. 5—GENERAL VIEW OF SET ON SITE

FIG. 6—STARTING CONTROLS AND INSTRUMENT PANEL

The Engineer

JUNE 21, 1940

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CHANGES OF ADDRESS.

**** Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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THE EMPIRE AGAINST GERMANY

AT this hour, when the Empire faces its destiny in circumstances more critical than at any time in its history, those subjects proper to our vocation elude us. Try as we may to pin our minds down to scientific, technical, or industrial problems, the war intrudes. We cannot escape from it. It interrupts consecutive thought upon any other subject. It creeps between the lines as our pen moves over the paper and insinuates itself into the shortest sentences. A hundred and one problems and anxieties crowd upon us, breaking down our concentration. Problems of the Empire, of Great Britain and her islands, of our works and factories and industries, of our cities and towns and hamlets, and even of our own homes and families. Yet in all this confusion of thought but a single purpose remains. The problem that we face is not how to elude or escape from the dangers that beset us, but how so to turn them to our advantage that in the end victory for all that we hold dear may be won through the tribulations, sorrows and sacrifices that we know await us. That is the end and object of all our thoughts. Not how to secure peace, but how, through trial, we can best direct all the powers and abilities and courage that lies in us to achieving the purpose to which we have set our hand. We are conscious that in this we do not write for ourselves alone, nor for a few handfuls of people here and there. We write not only for the great profession and industry which we have the honour to represent, but for all, save a few timid hearts, of the millions who compose the British Empire. The same resolve moves us all; to bear all and to win through whatever the bitterness that must be endured.

The first effects of a blow are always the worst. For an instant we are stupefied; then by degrees clear consciousness returns and we begin to see that things are not as desperate as they seemed for a moment. We take heart of grace, count up the cost, and rally our forces for renewed resistance and attack. When at midday on Monday the tapes told us in a few hurried words that France was seeking for terms of peace, consternation and depression fell upon us all. We had foreseen the coming disaster, yet hoped against hope that somehow, by some unknown means, it might be averted; yet when it fell upon us we were momentarily stunned. But in a few hours new hope, and, better still, new resolution came to our aid. We said to ourselves the war is not over because our gallant ally has received a mortal blow; we can, and we shall, fight on alone. And then we began to examine the position and found it far from being as desperate as for a bitter instant it had seemed. We reminded ourselves that if Germany had defeated France she had suffered enormously in the doing of it. She is not the military power that she was. She cannot command so many men and tanks and aeroplanes and ships as she did but a few weeks ago. She may have overthrown our great ally, but she is licking her own sores. And the task she has now set herself is very different from that which she has completed. She has not but to cross the Meuse, the Marne, and the Seine. She must throw a bridge across the Channel and establish a bridgehead on our shores. Until she has done that her vast array of tanks and armoured vehicles will avail her nothing. And that she cannot do until the command of the sea has been wrested from British hands. She must therefore rely upon the air, and the air is an element more fickle even than the seas. For days on end flying will be impossible even across the narrow seas. The weather, which favoured Germany throughout her land campaigns, will often be the friend of Britain, again, as it has been in the past. Furthermore, with the increasing output of the Empire and America our Air Force is ever growing and Germany cannot stop its growth. She cannot go overseas to bomb the factories of the Western hemisphere and the Antipodes. If she increases her squadrons of planes by capture or manufacture she will yet find it difficult to train pilots for them, whilst we shall be continually receiving recruits from safe training grounds far across the oceans. Hence the blows she may strike at us with her bombers will not be unavenged. She, too, will feel the terror that comes by night and leaves havoc behind. Her people do not yet know the full bitterness of war. They shall know. Turning our minds in another direction, we recall that for nine months Germany has been partially blockaded, as she is now almost wholly blockaded, against all seaborne commerce. Belittle as much as he may the effects of that blockade, the greatest pessimist cannot deny that it must have had some effect and that it has, and still is, weakening her power to continue a war of long and bitter duration. The pinch will be felt by Germany and by all the unhappy States which she has made her vassals as the autumn and winter come on. Against the angry murmurings of millions of people made desperate by hunger and with an army ill-fed her resistance will be sorely tried. Finally, yet indeed first of all, the British fleet is not only in being, but greater than it was and daily growing more powerful. It is the bulwark of our defence and not until it has been overthrown will Britain and the freedom she stands for bow to the conqueror.

Such thoughts as these give us courage and resolution to carry on the fight. With these things on our side the position is far from desperate, and there are others of which we know not yet the import and significance. America is stirring; Russia is an unknown quantity, but the alliance between her and Germany is of too brittle a nature to stand much strain; Germany must hold in a curb the nations she has dominated. Her very conquests may contribute to her downfall. Hence we may look at the pros and cons without despondency. Hard as the immediate future must be for us, it will be harder for our enemy. We are not beaten and we shall not be beaten. On that we are resolved. The well-worn words come back to us, breathing the spirit that has inspired this people for over seven hundred years and inspires it still:

> "Come the three corners of the world in arms,
> And we shall shock them. Nought shall make us rue,
> If England to itself do rest but true."

The End and the Means

THE end and object of our industrial effort is to give to our armed forces the fullest possible measure of support by the provision of every necessary form of munitions in the shortest possible time. The means to accomplish this end is to make the most logical use of the three main factors involved in production—plant, labour, and material—and to maintain the necessary balance between these factors, so that waste may be avoided. In every engineering workshop, whose output is in process of continuous expansion, lack of balance in one place or another is constantly manifesting itself, and bottle-necks and tight places are always arising. If the management is alert and far-sighted, bottle-necks will be anticipated and adjustments will be made to prevent them from becoming acute. If, on the other hand, there is a lack of vision on the part of those in control, bottle-necks will only be realised when they have already become acute, as in the case of the Dublin pilot, who recognised the position of the hidden rock only when his ship had crashed on it. There is a tendency to hope that bottle-necks will, with patience, rectify themselves, but unfortunately the workshop, unlike Nature, has no inherent and automatic power of adjustment, and lack of balance can only be avoided by imagination backed by continuous effort. If, in spite of the fullest use of all the foresight available, bottle-necks do occur, it is at least a hopeful sign if they move from one department to another.

Lack of balance manifests itself in many ways. It may be on a broad scale; for example, where the capacity of the fitting and erecting shops is in excess of the output of the machine shops. Here we get inefficiency, because while human nature is what it is, fitters cannot be expected to carry on with a good heart unless they are assured that they will not work themselves out of a job. On the other hand, we may have a broad lack of balance in the reverse direction, where the machine shop output is greater than the capacity of the fitters, with the consequent and wasteful accumulation of unfinished work which fills the stores and overflows into the shops, locking up material and labour in stagnant pools, instead of maintaining a constantly and rapidly flowing stream. In other cases, while the shops may not be out of balance on the broad scale, a constant succession of individual tight places is the general experience; the more so to the extent that the shop may be engaged in the production of several types of work in varying relative quantities. If, for instance, the normal output of an establishment consists of three classes of machines—A, B, and C—in relatively equal numbers all may be well, but if the demand changes materially the relative percentages of A, B, and C, then lack of balance may be anticipated as an inevitable result. In war time our target is a constantly increasing output, consequently our effort should be directed always towards the strengthening of the weaker links in the chain of production. If the fitters are behind the machine shop, additional fitting capacity must be provided, either by an increase in fitting shop space (although this is regrettable in war time, on account of the building expenditure and delay involved) or by introducing night shifts into the fitting shop, a practice which is by no means general, and which is frequently considered to present insurmountable troubles. Difficulties do, of course, occur in hand-

ing over the erection of a complex machine to a fresh gang of men, as it is not easy to preserve continuity of thought and action between the two gangs, but in all modern shops there is a large mass of fitting of components in which there is not the slightest difficulty in employing a night shift with success. Where the machine shop is the laggard, action is clear. Having first made sure that every machine is working at night as well as by day, then recourse must be had to the speeding up of operations, and, if necessary, to the provision of additional machinery or to putting out certain percentages of machining work to sub-contractors, if available. Lack of balance frequently arises, particularly under war conditions, by the delay in delivery of necessary material; then we get machines thrown idle and gaps arising in the continuity of the preliminary processes, which reflect themselves inevitably in subsequent similar gaps in the output of finished work. To maintain a hundred per cent. correct balance between all the departments of a workshop is an almost impossible task. Even a reasonable approach to it calls for the highest degree of vision and imagination, in which the buying department plays a leading part.

So much has been said about the lack of machine tools that an unfortunate tendency has arisen to look on machine tools as an end in themselves. In the present congested situation it is of vital importance to maintain clear thinking on this question. Machine tools are a means to production and not an end in themselves, and while masses of existing machine tools stand idle at night, to place enormous orders for new tools may sound magnificent, but it is certainly not war, nor is it a way to carry on war efficiently. No manufacturer of war material is helping the general situation if he buys new machine tools whilst identical machines already in his possession are not fully employed. So long as attention is concentrated on obtaining new machine tools to be worked during the daytime only, so long will labour be attracted from night shifts to day shifts. A workman naturally prefers to work by day rather than by night, but if the demand for labour on night shifts is increased and the demand for labour on day shifts correspondingly reduced, the position will rapidly improve. Workpeople will not leave night shifts for day shifts if the temptation to do so is removed. Let us remember that we still have two great sources of labour: first, the million or more of unemployed men and women; secondly, the masses of women, not customarily employed in the workshops, but quite willing and anxious to take such work when they are convinced of its necessity and when they are welcomed with open arms by employers and their fellow-workers alike.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE MEASUREMENT OF EARTH PRESSURE

SIR,—The article in your issue of May 31st by Professor Morrison and Mr. Cornish on the measurement of earth pressure reminds me of an investigation made between 1903 and 1907 for which a gauge to measure certain earth pressures was evolved.

It occurs to me that the story of the evolution and development of this gauge might be of interest, if not of use, to some one, even at this late date. It has never been published.

In the construction of the Pennsylvania Railroad tunnels under the North (Hudson) River, it became desirable to measure the pressures exerted by the silt on the tunnel. The first attempt was a cylinder into which the silt would flow, fitted with a spring-loaded piston which was screwed into the grout hole in the lining and provided with a scale to measure the deflection of the spring. This functioned for a brief time and then became fixed, and it was found that the water had drained out of the silt in the immediate neighbourhood of the hole, leaking past the piston. The silt thus became drier and harder and ceased to transmit pressure to the piston.

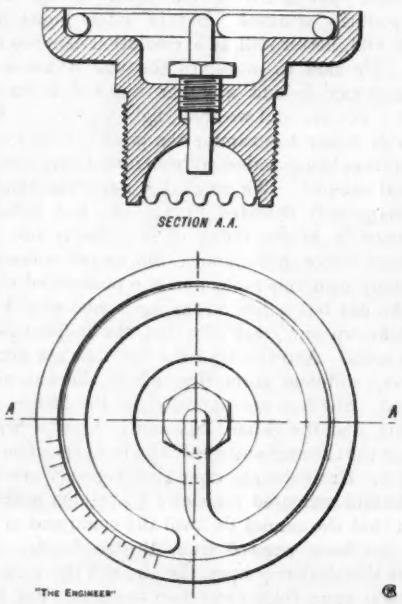
The next attempt substituted a corrugated metal disc for the piston. This acted upon a fluid which could enter a glass tube, sealed at one end in which was entrapped a quantity of gas. The length of tube occupied by this gas gave a measure of the pressure on the disc. At first the fluid was mercury, and the gas ordinary air. The mercury percolated through the disc and this was overcome by inserting a piece of very thin rubber between the disc and the mercury.

Then the small surface of mercury in the tube in contact with the air absorbed oxygen and thus diminished the volume of air and vitiated the readings. Finally, spirit with a little colouring matter was substituted for mercury and nitrogen was substituted for air. The arrangement is shown roughly by the sketch.

Each of these gauges was numbered (there were about a hundred of them) and calibrated both by weights and against a standard pressure gauge before use, and was taken out after a few weeks' service and recalibrated.

The earth was a very fine silt which flowed readily under pressure. Physical examination showed it to consist of fine flakes of clay and water. The water content was such that it could more truthfully be described as water, with particles of clay in permanent suspension.

As would be expected, it was found that the pressures varied with the level in the tunnel at which the gauge was inserted and with the position



ARRANGEMENT OF EARTH PRESSURE GAUGE

of the tunnel relative to the surfaces of the silt and overlying water. What was certainly not expected at that time was that the gauge readings varied quite regularly from hour to hour with the condition of the tide, and the readings, therefore, instead of being taken at the same hour each day, were taken at the same condition of the tide.

When gauges were inserted immediately behind the shield, they registered the movements of the tunnel and shield, and for the purpose in view the readings for the first few weeks after the erection of the lining—that is, until stability was reached—were neglected.

Of course, the gauges failed sometimes and readings became erratic. This could be detected immediately, and usually, when the gauges acting in this manner were taken out and examined, it was found that they had begun to leak either at the stuffing-box or between the disc and the casing.

The complete story, as yet unpublished, of this investigation, the results of which proved vital to the safety of a vast undertaking, would read like a romance of engineering.

H. T. HILDAGE.

Eyam, June 10th.

THE SCANDAL OF THE IDLE MACHINES

SIR,—Owing to this country's present perilous position, it appears we engineers ought to face the real facts and take our share of the blame.

During eight months of this most desperate war, with our splendid men fighting and dying day and night to save England, our works throughout the country have closed each night, and hundreds and thousands of machines remain idle, production stopped for airplanes, tanks, guns, and shells.

Is any engineer proud of such a scandalous position? Is this the way to combat the world's greatest military machine and prevent our defeat? Then, if not, why let it continue? Away with excuses, and let us get down to the job in real earnest. It can and must be done. Three shifts throughout the seven days each week. Honour to the very few firms already doing this.

Thousands more machines have yet to be delivered, and labour will be found for them, so why not use these men *now?*

Move up the semi-skilled and put on unskilled, as in the last war.

Let us admit that we have defaulted badly, but let us not admit our failure now—at this late date—to back up our fighting men and our country.

If His Majesty the King would visit works closed at night, to see machines all stopped, the shock would be impressive, and those responsible would realise their excuses were terribly out of date.

Engineers are noted for doing impossible things, and this country has a right to expect that at least they will keep their machines working. So from now on, let us ensure three shifts a day and a seven-day week.

CATMUR MACHINE TOOL CORPORATION, Ltd.,
T. S. CATMUR, M.I. Mech. E.,
Managing Director.
Burwood House, Caxton Street,
London, S.W.1,
June 12th.

Sixty Years Ago

RECONSTRUCTION OF THE TAY BRIDGE

LESS than six months after the disaster to the Tay Bridge a Bill was introduced into Parliament seeking powers to rebuild it. In our issue of June 18th, 1880, we gave particulars of the proposals included in the Bill. It was intended to raise £200,000 additional capital with borrowing powers for an equal amount. As the North British Railway Company was losing much money in conducting its traffic without the bridge it was intended to push on with the reconstruction as rapidly as possible. When the construction of the original bridge was sanctioned it was stipulated that at high water there should be a sufficient clear height beneath the central spans to permit ships to pass up the river to Perth. Many people thought this provision unnecessary in view of the small volume of river traffic concerned, but the plans went through with the central spans providing a clearance of 88ft. This clearance was achieved by constructing the central thirteen spans in the form of lattice girders carrying the rails at the level of the bottom booms. The rest of the spans—with the exception of one bowstring girder on the Dundee side—consisted of lattice girders carrying the rails at the level of the upper booms. The thirteen central spans not only rose to a greater height than the others, but were greater in length, two measuring 227ft. and eleven 245ft. After the disaster it was found that all the thirteen central spans had collapsed into the river. The adjoining and all the other spans of the bridge were intact. The plans for the reconstruction of the bridge involved lowering it to provide a headroom of 57ft. instead of 88ft., and the introduction of intermediate piers in each of the central spans so that in place of the original thirteen central spans there would be twenty-six with a length of 100ft. or slightly more. The regrading of the line to a lower level would have involved lowering the height of all the girders on either side of the central spans, but it was not proposed to alter the lengths of those spans. The line would be carried at the level of the top booms of the girders throughout the whole length of the bridge. It was not intended to depart from the original scheme of making the bridge carry a single line of rails, but the new piers to be constructed would be made sufficiently wide to take a double line if it were decided to widen the bridge for that purpose in the future. By a clause in the Bill the company sought power to delay the traffic across the bridge if, on account of severe weather, it was deemed necessary to place a temporary restriction on the use of the bridge.... A Select Committee of the House of Commons was appointed to examine the scheme proposed in the Bill. In July, 1880, it issued its report. It considered that it was expedient to rebuild the bridge, that the existing site was the most suitable that could be selected, and that the proposed design would not interfere with the navigation of the river. On the fourth point remitted to it—the safety and security of the proposed reconstruction—it came, however, to the unanimous conclusion that it was not justified in giving its sanction to the scheme. The Committee's decision was powerfully influenced by the Board of Trade, which objected energetically to the reconstruction of the bridge with a single line of rails, and strongly advocated that the whole of the existing structure, foundations, and all else, should be scrapped.

A SHAFT SINKING RECORD.—During April a new shaft sinking record was set up at the West Rand Consolidated Mines, when an advance of 441ft. was made in thirty days on a vertical shaft of six compartments, each 10ft. by 5ft.

Commercial Ozone

By A. E. WILLIAMS, F.C.S.

AS is well known, ozone is present in a small degree in the relatively pure atmosphere of the country and over the sea, but the heterogenous nature of a town atmosphere carries a much smaller proportion. First discovered by Van Marum in 1785, it was not until 1840 that another investigator, Schönbein, gave us the first insight into the nature of this gas. A molecule of oxygen is written as O_2, but a molecule of ozone contains another atom of oxygen and is expressed as O_3. This additional atom of oxygen in the molecule imparts to it a much greater oxidising power. Ozone, which owes its value in commerce to its oxidising capacity, may therefore be termed active oxygen. The difference between ozone and oxygen can be seen from a glance at the following table of characteristics.

	Oxygen.	Ozone.
Molecular weight	32	48
A cubic foot weighs, at 15 deg. Cent.	40 grammes	60 grammes
A litre weighs, at 15 deg. Cent.	1·430 grammes	2·145 grammes
Boiling point, deg. Cent., at 760 mm....	−181·5	−119
Oxidising capacity ...	Feeble	Very powerful
Odour and colour ...	Nil	Pungent, bluish

Ozone is an endothermic gas, its heat of formation being approximately 33,000 gramme-calories per molecule. At room temperature it does not readily split up into oxygen unless in contact with any easily oxidisable substances, but at elevated temperatures it reverts to ordinary oxygen. Ozone may be produced by a variety of methods. Besides being created by some chemical reactions, it is formed by the evaporation of water, by incandescent bodies, radio-active elements, ultra-violet rays, electrolysis, and by the electrostatic field. The latter method is the one most widely used commercially; and, incidentally, in the operation of many types of electrical apparatus the fortuitous production of ozone can be detected by its characteristic odour.

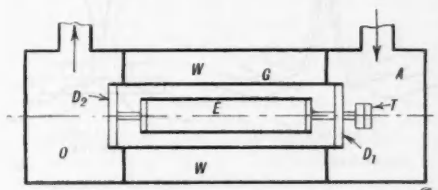


FIG. 1—DIAGRAM OF OZONE GENERATOR

A commercial ozone generator usually operates on the principle of silent discharge. The theoretical side of ozone formation under such conditions is not yet fully understood, but it is generally accepted that ionisation by collision occurs, causing dissociation of some of the oxygen in the immediate vicinity of the electrodes which oxygen on re-combination furnishes aggregates of ions made up of molecules carrying an attached extra atom of oxygen. Ozone generators working on the silent discharge principle may be regarded practically as condensers; for a series of discharging surfaces or electrodes is arranged, in pairs, at a suitable distance from each other, so as to form condensers a material of suitable dielectric strength being placed in the air gaps. The electrodes themselves may be in the form of flat plates or of tubular shape. In some types of ozone generators the electrodes are constructed of solid metal, often stainless steel, and owing to the heat generated when in operation a water cooling system has to be introduced. A typical generator with solid plate electrodes consists of a series of four plates, the area of which depends on the output of ozone required. Air is drawn in at the peripheries of the plates and is passed at a predetermined rate through the electrical field, which converts a portion of it to ozone and then through the two outer plates which have an outlet in the centre for this purpose. Attached to the two outer plates is a water jacket, which is earthed. A similar water jacket is interposed between the two inner plates, being electrically coupled to these two plates. The inner water jacket serves as the high potential element of the generator and it is therefore insulated from the surrounding apparatus. When in operation water is constantly circulated through the jackets, but to avoid appreciable leakage of current in the high potential side the water is allowed to fall through the air, into and out of the inner jacket, a distance sufficient to prevent such leakage.

In an ozone generator of the solid tubular type the tubular electrodes are fixed coaxially within tubes of glass, the latter being surrounded by cooling water, which is also earthed, whilst an appropriate gap is left between the outer glass tube and the inner metal tube (the electrode) to permit air to be passed through. The high potential current is led to the electrodes through insulated bushings at one end of the tubes, and it discharges across the gap, through the glass tube and so into the earthed water. Fig. 1 is a diagram showing the principle of operation of a solid tubular electrode generator, in which A is the air chamber and O the ozone chamber. When in operation high potential current is switched on to the tubular electrode E through the terminal T. The discharge passes through the glass cylinder G and into the water jacket W, which is earthed and entirely surrounds the glass cylinder. The suction end of a blower is connected to the ozone outlet at O, thus drawing a current of air from A, through the first perforated insulation disc D^1, which supports the electrode at the correct distance within the glass cylinder. The air passes over the surface of the electrode and out, as ozonised air, through the other perforated insulation disc D^2 into the ozone outlet. In other types of generator the electrodes are of alloy metal gauze, which not only provides a greater surface area, thereby increasing the efficiency, but they may be cooled sufficiently by the surrounding air, thus dispensing with water cooling. Owing to the use of gauze as an electrode the discharge of electricity is spread over a very large number of points, so keeping the discharge density factor very low.

In every case it is an essential feature of a generator that it be kept cool, even when operating over long continuous periods, as it is often required to do, for the heating up of the apparatus causes formation of nitrogen oxides from the surrounding atmosphere, and also the splitting up of ozone already formed. In some cases, depending on locality and other circumstances, it is necessary for the economical operation of the ozone generator that the air be as dry as possible. To this end several methods for drying the air before ozonising it have been adopted, such as passing it through various chemical substances to absorb the moisture, but often the most satisfactory plan is refrigeration. In this latter method of air drying it is the general rule not to cool the air much below zero Centigrade, because although on further cooling the economy of the ozone generator increases, the extra cost of refrigerating to such lower temperatures usually outweighs this economy.

Not many years ago ozone generators were commonly operated on relatively high voltages, generally 5000 to 20,000 volts, with frequencies ranging from 50 to 500 cycles per second and special high-frequency electrical generators had to be employed with the ozone apparatus. A modern ozone generator, however, has a dielectric of special material fixed between the electrodes, which material allows of the efficient operation of the apparatus at a much lower voltage and periodicity. The latter may be as low as 25 cycles, while the voltage, even for high concentrations of ozone, seldom exceeds 5000. A modern ozone generator enables a much higher efficiency to be maintained than was ever possible with the older apparatus. For example, at low ozone concentrations, as used for ventilation, &c., about 300 grammes per kilowatt is obtained, and at very high concentrations the yield is around 150 grammes per kilowatt. An essential feature of the electricity supply for ozone generators is that it must be single-phase alternating current, but where only direct current is available it is a simple matter to install a converter, which may be of the rotary type.

Amongst the numerous applications of ozone to industry the treatment of water is a prominent one, particularly in war time, when, owing to the exceptional circumstances, waters which in normal times are not required as potable supplies must be pressed into service. In numerous cases in this country towns' water supplies are subjected to ozone treatment, a recent example of this being the ozonisation of the water at the Huntington pumping station of the South Staffordshire waterworks. The ozone generators at this station were supplied by the Paterson Engineering Company, Ltd., 83, Kingsway, W.C.2, and consist of eight units, each unit being made up of six stainless steel electrodes, a glass cylinder surrounding each electrode. The glass cylinders are immersed in earthed water, and both they and the electrodes are visible from without through glass panels inserted in the outer casing. These casings are fitted with the necessary water control valves and also a neon lamp to give warning when the apparatus is working. The ozone generator is enclosed by a series of interlocking doors, so wired that should one of these be opened when the current is on the frequency changer on the circuit supplying the electrodes is cut out and the generator becomes dead. The cost of sterilising water by ozone is practically confined to the initial outlay for the plant, since operating costs are very low. Naturally, running costs vary with the nature of the water to be treated, but in general, for an expenditure of one unit of electricity 5000 gallons of water can be sterilised in a fairly large installation, smaller plants being almost as economical.

Until recently it was the general practice to sterilise the water of swimming baths with materials of a chemical nature, but in many cases this procedure had serious defects, in that it caused

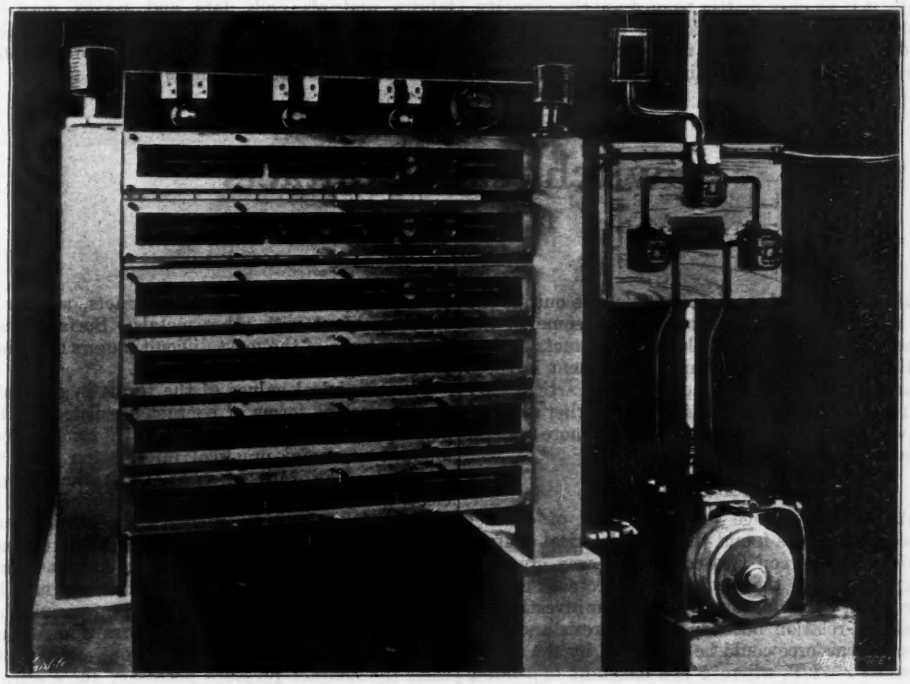


FIG. 2—TYPICAL MODERN OZONE GENERATOR

irritation of the skin, eyes, &c., and thus served to lower instead of to increase the popularity of the swimming pool. Within the past few years many of the modern swimming baths have been equipped with ozone apparatus. The chief advantages of using ozone for this purpose are that there are no chemical products left dissolved in the water and its cost is often lower than that of chemical sterilisation. An ozone generator, by Bruce H. Auld and Co., Ltd., 161, Stafford Road, Croydon, used for swimming pool sterilisation, is shown in Fig. 2. This apparatus is of simple construction and the various parts of it can be recognised in the illustration. In the bottom right corner is a rotary blower, direct-coupled to a small electric motor. To the suction end of this blower is connected a pipe leading to the chambers on the left, in which the ozone is produced. The necessary transformers to step up the voltage of the town supply to that required for ozone production are placed behind the vertical trunkings and insulated from the main frames. At the top of the two supporting columns are seen two cylindrical containers. These are filters through which air, drawn by the blower, passes to get rid of suspended impurities before contacting with the ozone producers. Immediately over the latter is an ammeter on the right, and switches for controlling the number of ozone-producing units in operation, this number generally depending on the number of people in the swimming pool. The pipe over the main switchgear on the right conveys the ozonised air to the bath. In a plant of this description, built up of sectional units, it is an easy matter to increase the capacity, if necessary, by adding further units. The electrodes are of the tubular type and constructed of special quartz, water cooling not being necessary, and the surrounding casings are treated on the inside with an electrical deposit to withstand the action of the ozone, which at this point is concentrated. A glass window is fitted in front of each horizontal casing, through which the ultra-violet ray around each generating element may be seen. Wide variations in the output of the apparatus and economy in operation are possible, as every two rows of generating elements are wired to a separate transformer. For a swimming bath of 100,000 gallons the appropriate apparatus would consist of eight rows of ozone generators. Under normal working conditions very little attention need be paid to the upkeep of the generating elements, beyond removing any deposit, which may have formed, at the end of every three months or so. In order to ensure even distribution of the ozone throughout the whole length of the bath a motor-driven rotary compressor is used to deliver the ozonised air both to the bath delivery main and also through a series of jets laid in the bath floor. From this it will be seen that the blower operates against only a low-pressure equivalent to the maximum depth of water in the pool. If this depth is 10ft., for example, it would correspond to a pressure of about 4½ lb. per square inch.

Besides water treatment, ozone has long been used in ventilation schemes and in destroying noxious odours from sewage plants, chemical works, &c. Its use in brewing for sterilising casks, bottles, &c., and also in improving the qualities of the yeast is an established practice. Many organic materials, such as cotton, silk or linen fabrics, and also oils, fats and waxes, may be successfully bleached with ozone, whilst in the drying and thickening of oils for varnish and insulation manufacture ozone is a useful adjunct.

Switchgear Contacts

By G. WINDRED

No. I

THE object of the present article is to outline the major considerations relating to some of the practical applications of electrical contacts and to indicate the trend of recent development in these branches of electrical practice. The article may be regarded as supplementary to an earlier article,* to which the reader is referred for a more general treatment of the subject.

Contact Resistance

At an early stage in the history of contact researches it was found that the electrical contact resistance between two conductors was inversely proportional to the mechanical force acting upon them. It was in fact assumed by some investigators that the relation between contact resistance and mechanical force could be expressed by the simple formula $r = k/P$, where k is a constant depending upon the physical arrangement of the contact and the materials employed, and P is the mechanical force expressed in appropriate units. The factor P is usually referred to as the contact pressure, and is measured in lbs. or Kg.

More recent investigations† have shown that this simple relationship applies in only a few cases, and that in general the contact resistance is given by

$$r = k/P^n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The exponent n varies, according to the type of contact, between the limits of 0·5 and 2.

Contact resistance is considerably affected by the state of the contact surfaces, as well as their shape. For this reason it is necessary in practice to allow for the effects of surface films such as oxides, which are invariably present to some extent in the case of copper contacts, and to a varying extent with other metals. Surface films represent one of the most difficult factors applying to the design of electrical contacts.

Type of contact	Condition	n	k
Cylinders crosswise ...	Theoretical	½	0·000150
Cylinders crosswise ...	Empirical	½	0·000205
Contact finger	Line contact... ...	½	0·000330
Plane, 1·6 cm²	Normal finish ...	1	0·000430
Plane, 1·6 cm²	Normal finish, lubricated	1	0·000340
Plane, 1·6 cm²	Tinned	1	0·001250
Plane, 3·2 cm²	Ground, new ...	2	0·4000
Plane, 1·6 cm²	Ground, new ...	2	0·0500
Plane, 0·8 cm²	Ground new	2	0·0100
Plane, 1·6 cm²	Ground, much used	5/3	0·00190
Plane, 1·6 cm²	Ground, lubricated	4/3	0·00280
Plane, —	Ground, oxidised...	⅔	0·00170

The numerical values of the terms in equation (1) for various forms of contact are listed in the accompanying table, from which a considerable amount of useful practical information may be deduced. The rate of heat generation in an electrical contact is proportional to I^2r, where I is the effective value of the current and r is the contact resistance. It follows that if the resistance can be calculated, then the permissible current rating of the contact for a given temperature-rise may be determined. Alternatively, if the permissible current rating for a given contact arrangement and a particular pressure is known from experiment, then the contact pressure necessary for ensuring the same temperature-rise of the contact while carrying some different value of current may be calculated.

In order that the temperature-rise may remain constant, we know that in general the value of I^2r in the contact must also remain constant, so that we have

$$I^2r = K \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

From equation (1), we have by substitution

$$K = I^2k/P^n, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

from which it is seen that for a given temperature-rise, P^n must bear a constant relationship to I^2. Since the exponent n is constant over a wide range of pressure for a given type of contact, it follows that the contact pressure P_1 for any arbitrary current I_1 can be calculated from equation (3) as follows

$$P_1{}^n = I_1{}^2k/K \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

If, for example, the contact is of a type in which the contact resistance is inversely proportional to the square of the pressure ($n=2$) and it is known by experiment that with a pressure P the permissible current is I, then for a current I_1 of twice this value the rate of heat generation as represented by equation (2) would be four times as great. It follows that for a constant value of K in equation (4), representing a reduction of the rate of heat generation to the original value, the condition $P_1{}^n = 4P^n$ must be fulfilled. For the case in question, where $n=2$, this means that the pressure must be doubled.

These relationships are of considerable importance in switchgear design, and represent a rational basis for the determination of contact pressures. At present such determinations are usually based upon purely empirical or arbitrary procedure. It is to be hoped that in due course a more scientific approach to the problem will be adopted, along the lines which appear to be feasible on the basis of the foregoing considerations.

Effects of Arcing

It is not necessary to emphasise the damaging effects of arcing upon switch contacts. During recent years a large number of different types of arc control devices have been produced, with the object of reducing the arc energy during circuit interruption and thus prolonging the contact life. Most of these devices are intended for use on alternating current circuits, and are thus concerned with producing the most rapid possible rate of increase of dielectric strength in the arc gap, following disappearance of the arc at the first zero point of the current wave. Full descriptions of these devices have been published from time to time.

A very important factor in the design of heavy current switchgear is the avoidance of harmful electromagnetic forces acting in such a way as to reduce the normal contact pressure. This condition is very undesirable in the case of heavy current switchgear, or when high current peaks are likely to occur. It arises whenever the lines of current-flow through the switch contacts are doubled back upon each other so as to result in two current paths lying close together and having opposite directions. The conditions are made clear in Fig. 1, relating to contacts of the type used in air-break and oil-immersed contactors. Such contacts are usually arranged to touch first at a region near their tips, as shown at (A), after which the closing motion results in the region of contact moving down until in the fully closed position the current is conveyed across the lower parts of the contacts, as shown at (B). During the opening process, the motion is reversed, and the circuit is broken at the tips of the contacts. It follows that these regions are subjected to any arcing which may occur both in closing and opening the circuit. This arrangement is intentional, since it ensures that any pitting and erosion due to arcing occurs on parts of the contacts removed from those which convey current in the fully closed position.

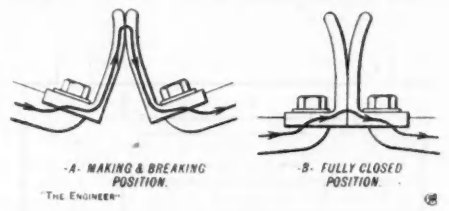


FIG. 1

It will be observed that the opening and closing positions, as represented at (A), are especially conducive to electromagnetic reactions, since the respective contact currents which flow in opposite directions are close together over a considerable portion of their length. The force of repulsion between the contacts resulting from this condition is considerably augmented if the current during connection or disconnection is greater than normal, as in the case of short-circuits, for example. Under these conditions there is a reduction of contact pressure, or even actual separation of the contacts, leading readily to welding or bad pitting. The effect is particularly important when making A.C. circuits, since the instantaneous initial current peak can amount to 2·5 times the normal steady-state R.M.S. value.

Similar contact conditions are brought about by any tendency for them to bounce when they come together, as is likely in the case of high-speed switchgear with butt contacts. In some cases the contacts may actually part several times before final continuous contact is established. At each separation an arc will normally be established, and will be quenched when the contacts come together again, so that during the closing process the contacts are subjected to the effect of the successive arcs. If high inrush currents are dealt with under these conditions it is evident that high rates of contact erosion are to be expected.

Contact constructions are available in which the tendency to bounce is overcome by arranging for the energy of the moving contact member to be absorbed by a resilient stationary contact member. At present the application is limited mainly to small and medium size contacts, but there appears

* G. Windred, "Electrical Contacts," THE ENGINEER August 30th, 1935, page 222.

† E. Contius, "Der Einfluss der Grösse des Druckes und der Fläche auf den Kontaktwiderstand," dissertation from the T. H. Dresden, 1929.

no good reason why it should not be developed for heavy-current switchgear where massive butt type contacts are employed.

(To be continued.)

The Salvage of H.M.S. "Thetis"*

By G. R. CRITCHLEY

AN account of the salvage operations requires the prefix that although the Liverpool and Glasgow Salvage Association was entrusted with sole responsibility for and control of the operations as from June 9th, 1939, the Association received vital assistance from naval deep sea divers attached to H.M. Diving Ship "Tedworth," under the command of Lieut. Commander W. J. Stride, R.N. An early report from the Association's salvage officer stated :—

> "The 'Tedworth' divers and their organisation are of very great value, and the control of this unit is the admiration of everyone on the spot."

This admiration deepened as the work proceeded, and these divers responded without hesitation to every requirement, often under conditions which would have justified some demur. Other examples of Admiralty assistance, given with such readiness by the Controller of the Navy that the author felt no compunction in making requests, are described in the narrative.

A member of the Institution, Mr. A. M. Robb, D.Sc., who has acted as the Association's technical adviser for some years, was employed to supervise the work of adaptation of a merchant ship as a lifting unit, and to calculate the stresses to which that vessel and the submarine would be subjected by the lifting operations. His calculations are used in the narrative.

The submarine was sunk in position 348 deg. 15 miles from Great Orme's Head light, in a depth of 25 fathoms at low water spring tides. The average tidal range was determined by actual soundings, and was found to be 22ft. with a surface velocity reaching 4 knots. At times there was no period of slack water, and at best the slack water period did not exceed thirty minutes. The significance of these facts was (i) the position was exposed from all quarters, and the worst sea conditions could be expected with prevailing south-west through west to north-west winds. The Association's long experience supported the view that the ordinary type of dumb lifting camel used by harbour authorities for raising wrecks from navigable channels would be quite useless under these conditions, because even in moderately bad weather they would be completely unmanageable, afford no protection for a working party whom it might indeed be very difficult to take off from the open and unprotected decks, and it is notorious that weather conditions are subject to very rapid change in Liverpool Bay. This was, in fact, demonstrated at the time of the Mersey Docks and Harbour Board's unsuccessful attempt on June 7th, when, under favourable conditions, the camels were pinned down at 9.30 p.m., but with the incoming tide conditions quickly deteriorated to moderate breeze and moderate swell, in which the camels rolled and laboured heavily, and about midnight the after wires successively parted and the forward wires had to be hurriedly slipped ; (ii) the depth of water and the tidal velocity were both adverse to the work of divers. At the minimum depth of 25 fathoms, which involved divers working at a pressure of 66 lb. per square inch, sustained manual effort was impossible, and the tidal velocity would prevent divers descending, except during slack water. Divers cannot keep position in normal working depths—that is, up to 80ft.—in a current of more than 2 knots. The significance of the work of divers in this case was that whereas in shallower water and dealing with a merchant ship wires can generally be swept under the wreck by surface vessels, in this case that method was useless, because there could be no certainty concerning the position of the wires by the method. The ballast keel of the submarine partly embedded in the sea bottom would obstruct a passage of wires along the bottom ; there would be fouling of hydroplanes ; and cutting of the wires owing to the form of the structure if they were slung at particular positions under the fore-end of the submarine. The divers were therefore essential to pass reeving wires in predetermined positions and to check the positions of the lifting wires.

The decision to reject dumb lifting camels for use in this case led to the adaptation of a merchant ship as a lifting unit, and the considerations affecting the choice of such a ship and her relation to the risks and requirements of the service were that she should be of approximately equal length to the submarine, and certainly not shorter ; that her deck plan should permit us to arrange eight lifting beams athwartships, so spaced as to be approximately vertical to selected positions along the length of the submarine for the placing of the wires, so that as the submarine was carried into shallower water, and consequently was brought up closer to the lifting unit, none of the wires should assume a very acute angle, and that the four forward beams, on the one hand, and the four after beams, on the other hand, should be capable of symmetrical distribution before and abaft the centre of buoyancy of the lifting unit, so that she would not materially alter trim under the load. Further considerations were that she should have generous ballast tanks so as to preserve stability with the heavy beams and other salvage gear placed on deck ; that she should not fine too rapidly at the ends because the method of adaptation would necessitate the transfer of the load from the decks to the tank tops through struts erected in the holds, and the greatest possible breadth at the ends was desirable for a wide distribution over the tank tops, because a narrow tank top would have involved excessive concentration of the load and would also have involved an excessive slope of the struts from the underside of the deck edge to the tank top, thus forfeiting the value of the struts when under compression by converting their resistance to that of almost pure bending. It was also necessary that the lifting unit should have space for the fitting of sleeping and feeding accommodation for a salvage party of about fifty men, in addition to the navigating personnel, so that the whole unit could be self-contained, and organisation thus simplified, whilst in the event of bad weather there would be a minimising of risk to personnel, and if it should become necessary she could slip the lifting wires and her moorings and take care of herself by means of her own engines.

A widespread search was made throughout the country, and the plans of numerous vessels were obtained. The most likely vessels were inspected, and in the result "Zelo" was chosen as meeting most nearly the aforementioned requirements. She was 308ft. long and 43ft. beam, in contrast with the submarine's length of 275ft. overall and 26ft. 6in. beam overall. Her deadweight carrying capacity was 3350 tons, inclusive of 450-ton bunkers, and the submerged weight of the submarine was said to be about 1000 tons. She had a total water ballast capacity of 1036 tons, of which 73 tons were taken in ballast tanks on the port and starboard sides of the tunnel. Fresh water for boiler feed and drinking could be carried in two tanks in the engine room, which were initially installed for oil fuel. Her tons per inch immersion between the ballast condition and the contemplated loaded condition was 35, and thus only a small part of the total rise of tide was lost by the mean sinkage of the lifting unit.

The vessel at the time was lying at Cardiff under Admiralty charter, and it was easy, with the help of the Admiralty, to secure immediate cancellation of this charter and the placing of the vessel at our service.

It was considered desirable to use eight slings, each of 9in. wire. The nominal breaking strain of wire of that size, which is constructed of six strands, each consisting of sixty-one wires of best quality galvanised steel, laid clockwise around a hemp core, is about 240 tons. In fact, twelve wires, each 120 fathoms long, four of which were to be held in reserve in case of breakage, were constructed and delivered by the Rutherglen works of British Ropes, Ltd., in the record time of twelve days, and were tested to a breaking strain of 265 tons. That gave a factor of safety of 4 in the wires, assuming uniform loading, and a larger safety factor than was to be provided for the means of attachment to the lifting unit. That may seem *prima facie* to be the reverse of normal practice, which aims at a greater margin of safety in the means of attachment than in the wires themselves, but the answer to that apparent divergence from practice is that it was assumed that ten lifts would be required to take the submarine into shoal water, and that there would be considerable chafage and consequent weakening of the wires, and also that as some of the wires would pass over the sharp edges of the ballast keel they might be severed, either completely or partially.

The athwartship lifting beams fitted on the deck of the "Zelo" were constructed of square pitch-pine logs, each beam being built up of four square logs, the ends of which overhung the deck of "Zelo" on each side 3ft., and were formed into bobbins by means of beech segments laid over the outer surfaces of three of the logs, and by greenheart segments laid over the outer surfaces of the fourth log in an order which met the condition that the wires would be taken round the bobbins and would be belayed in the clockwise direction, coming up on the aftersides of the beams on the starboard side of the lifting unit, and on the foresides of the beams on the port side of the lifting unit. This clockwise winding of the wires around the bobbins conformed with the clockwise lay of the strands of the lifting wires. The greenheart segment formed the top quarter circle of the bobbin with which the lifting wire made contact as it entered upon its first turn round the bobbin, and the soft beech segments were used to permit the wires to bite into them to increase frictional resistance to slipping. Such an arrangement of lifting beams had commonly been used by the Association in salvage operations, but never on such a scale as was necessary in this case. Moreover, timber beams have previously been used because (i) construction is quicker than in the case of steel girders, and (ii) timber usually gives adequate warning before any serious fracture occurs.

Fig. 1 shows details of the lifting beams and under-deck stiffening. It was considered desirable to support the beams on "grillages" with soft wood packing, such as is used in the construction of fore poppets, in an endeavour to distribute the load over the portions of deck between bulwarks and hatch coamings on the lifting vessel. The effect of the soft wood packing and the consequent indeterminate distribution of support was that the exact magnitude of the bending moment was not known. Moreover, it was considered necessary to reinforce the beams by fitting wire "ties" secured around cross-beams on the inner bottom of the ship. As the tension in the wires was not known, another indeterminate element was introduced. It was, however, possible to determine the limiting values of the bending moment. In the result, there was a fairly wide range of possible bending moment, but there was not a very wide range of possible beams to resist this moment. It was possible to obtain thirty-two pitch pine logs of sizes ranging from 12in. square to 16in. square. In the groups of four these were arranged with the larger logs placed nearer amidships in the lifting vessel, because it was expected that the loads would there be greater. With such an arrangement the stresses due to bending moment were not large.

The consideration of the resistance to twisting moment was more difficult. On an ordinary approximation to the strength of the rectangular section, and on the assumption that in each beam the four logs acted independently, the stresses were high. A cruciform $\frac{3}{4}$in. steel plate was therefore interposed between the four grouped logs at each end of each beam extending completely over the region of support, and the ends of the beams were bound together when the bobbins were formed. Further, in way of the hatch coamings they were buttressed by fore and aft logs fitted between the beams, and from the end beams down to supports on the deck. It was not possible to arrange similar buttresses near to the outboard ends of the beams because this would have impinged upon the working space in the regions of the bobbins. It was believed that this arrangement provided adequate resistance against twisting moment. Fig. 2 shows the arrangement of the beams on the fore deck of the lifting vessel and Fig. 3 shows the under-deck supports and stiffening. It should be noted that the disposition of the stiffening was governed in part by the desire to tie the beams at the mid-lengths, which explains the arrangement of cross-beams and diagonal struts.

The Association's experience was that with three complete turns of a 9in. wire round each bobbin

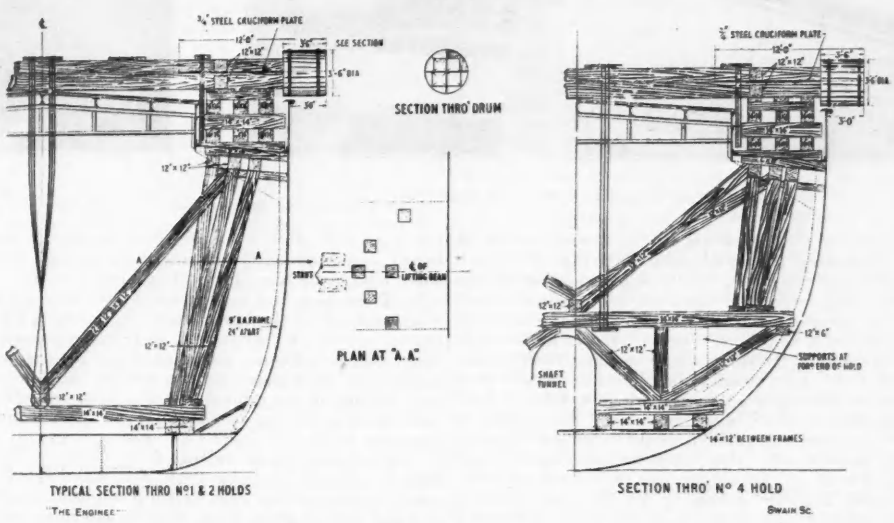


FIG. 1—*Lifting Beams and Under-Deck Stiffening*

* Institution of Naval Architects. Released forthwith for written discussion.

the free end of the wire could be held by a light tackle with a pull of less than 1 ton, and the method of "pinning down" at low water was to heave up the 9in. wire on either side of the lifting craft with the ship's derricks and winches, and when the wires had been hove to maximum tautness they were secured at a point immediately below the bobbins by clamps and the free ends worked round the bobbins. In the event of one or more wires taking an unequal proportion of the load, release could be obtained by rendering such wires by means of the tackle.

So much for the lifting vessel.

It became necessary to give consideration to the question of the strength of the hull of the submarine to withstand the stresses imposed by the contemplated method of positioning the wires, having regard to the fact that the salvage officer in charge at that time desired approval to the positioning of four wires just forward of the fore end of the ballast

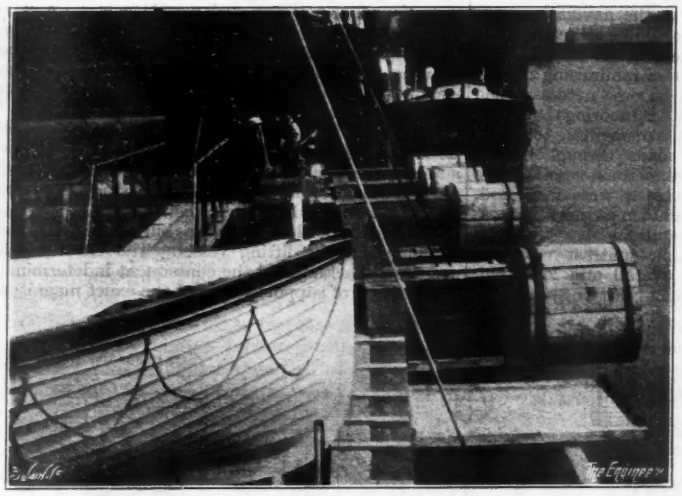


FIG. 2—*Arrangement of Beams on Fore Deck*

keel, and four wires abaft the keel, with a view of (i) eliminating the anticipated difficulty of placing wires under the keel; (ii) avoiding the risk of the wires being cut by the sharp edges of the keel; and (iii) avoiding damage by the wires to the external ballast tanks, *i.e.*, the side tanks. It was known that by this method the slings would be about 188ft. apart.

Dr. Robb, by a rough approximation, advised that upon an assumption that the whole weight of 1000 tons was uniformly distributed over this length of 188ft., the bending moment would be 23,500 tons-feet, and, alternatively, that upon an assumption that 90 per cent. of the weight was thus uniformly distributed, and the remaining 10 per cent. acted at 20ft. beyond each sling, there would be a bending moment of 20,150 tons feet. On the first assumption the tensile stress on the material of the pressure hull would be about 15·3 tons per square inch, and on the

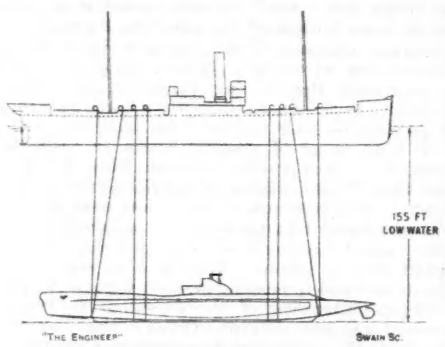


FIG. 4—*Positioning of Wires*

second assumption about 13·1 tons per square inch, and in his view these stress figures were not so high as to render the proposed method inadmissible. The author, however, considered that the concurrence of the Director of Naval Construction was at least desirable, because we were not in possession of complete information concerning structural details, and we had been officially informed that every care was to be taken to avoid disturbance of the structure forward of No. 40 bulkhead, so as to preserve intact that part of the vessel for the purpose of evidence for the public tribunal.

A concentration of four wires upon a small area in way of the spaces which were vital for the purpose of evidence might have resulted in these wires cutting through the pressure hull or causing disturbance, which would have defeated one of the objects for which the salvage operations were undertaken, and accordingly an interview with Sir Stanley Goodall was sought and granted. He concurred in Dr. Robb's estimated stresses on the assumption that the submarine was completely flooded fore and aft, disregarding possible air locks. If, however, one or more of the main compartments remained watertight, the pressure hull in that neighbourhood would be subjected to stresses due to the depth of water which would perhaps be as much as 8 tons per square inch, and in that case the total stress would be of the order of 17 to 20 tons per square inch, and a stress of that magnitude might have serious effect. The result of the discussion was that we agreed to place two lifting wires under the keel forward of the conning tower and two under the keel abaft the conning tower, so that the positioning of the eight wires would be as shown in Fig. 4.

Whilst the work of adapting the lifting unit was in progress, our salvage steamer "Ranger," accompanied by H.M.S. "Tedworth," was engaged at the case, first ascertaining the precise direction in which the submarine was heading, which was found to be south 80 east, with a list of 15 to 20 deg. to starboard; ascertaining the nature of the ground, which was found to be blue clay with a mound on the port side of the bow and a hole about 8ft. deep on the starboard side of the bow; attaching marking buoys to the ends of the submarine, and clearing away all wire *débris*. These preliminary operations also resulted in disclosing that the keel at the fore end was slightly off the ground, but the stern had settled into the bottom up to the level of the starboard propeller boss.

"Zelo" was ready to sail from Cammell Laird and Co.'s basin on June 28th, but was held there owing to a southerly gale, and did not sail until the evening of June 30th, when weather was moderating. Conditions were still unsettled, and there was a critical interim stage between the time when she could be placed over the wreck and heavy ground moorings laid out from the four quarters as well as from ahead and from astern, during which fine weather conditions were essential, and it was not until July 4th that she could be moored in position.

Weather prevented divers descending until the morning of July 6th, when reeving wires were passed by the divers under the submarine's bow immediately forward of the keel, but on the night of that day weather rapidly deteriorated and became a whole south-westerly gale with heavy sea, and in the early hours of the morning on July 7th "Zelo's" starboard moorings dragged and she broadsided to the gale, carrying away two heavy bollards and fracturing the bases of other bollards on the forecastle and poop. As there was no sign of improvement of weather conditions, she was instructed to return to Cammell Laird's basin.

At this stage it is appropriate to interpose the point that as large-scale charts showed unevennesses of the sea bed between the position of the casualty and the east side of Anglesey, to which it was intended to carry the submarine, and the presence of wrecks in these waters was also known, it was considered advisable for the whole area to be carefully surveyed, and a course plotted which would give the clearest possible path during the movements inshore, and the Controller of the Navy was good enough to place at our disposal the services of H.M. Survey Ship "Gleaner" for this purpose.

In addition to carrying out the main purpose of her service, "Gleaner" also ascertained the somewhat disturbing fact that sub-surface tidal currents ran in a direction which was sometimes as much as 60 deg. divergent from the surface current. Whilst it was quite possible that in the Association's experience lifting operations had been conducted where a similar condition had operated, we had never previously had such scientific assistance as disclosed the fact to us, and therefore an unknown factor was introduced into the case, the effect of which could only be to a considerable extent surmise. These divergent surface and sub-surface currents, however, accounted for the excentric behaviour of the reeving wires at a later stage of the operations, and in particular reference is made to one instance where a reeving wire was passed by divers through the aperture between the pressure hull and a guard bar at the fore end of the keel, the intention of which was to confine the wire and prevent its sweeping further forward and being damaged. It was later discovered that between one tide and the next the port leg of this wire had been swept right round under the bow of the submarine to the starboard side, and as it was locked in the aperture by the guard bar we were unconsciously attempting the futile procedure of heaving a 9in. lifting wire round the guard bar and bringing both ends up on the starboard side of the submarine, with the result that if the situation had not been discovered this wire would have failed to function as a bight carrying its share of the load. Owing to the depth of water, there was no surface manifestation whatever of this condition, and the

FIG. 3—*Underdeck Supports and Stiffening*

incident serves to illustrate the importance of the naval deep sea divers at the case.

Whilst new bollards were being fitted to "Zelo" consideration was given to the point of improving the heavy ground moorings in order to avert a recurrence of the dragging of the moorings which had occurred during the south-westerly gale. It was realised that although the weather conditions experienced at the case were abnormal for the time of the year, and a whole south-westerly gale might not recur during the subsequent operations, it was, nevertheless, considered prudent to revise the system of ground moorings. The question was how this should be done. Our practice of rigging ground moorings to heave off a ship which is aground is to shackle the heaving wires to manilla purchases which are laid along the deck of the stranded vessel. These manilla purchases act as springs which absorb shocks coming upon the

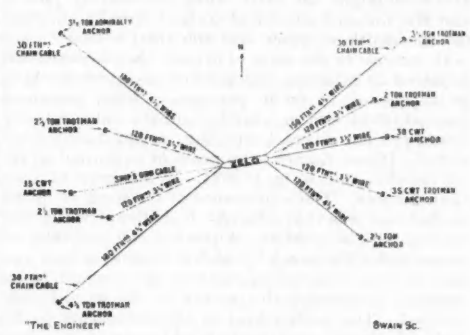


FIG. 5—*System of Moorings*

moorings in bad weather, in addition to their function as heaving appliances. That device was, however, impracticable in the case of "Zelo," because the purchases laid along her deck would have obstructed the manipulation of the lifting wires. It was eventually decided that as an alternative to manilla purchases we would interpose not less than 30 fathoms of stud-link cable between each of the main salvage anchors and wires, to act as springs in case of bad weather. This method was not adopted in the first instance because moorings of this character are very heavy, and it was felt that as "Zelo" was towed inshore carrying the submarine from the first position to a second, and subsequent positions, it would be impossible for "Ranger" to lift these heavy moorings and relay them so as to secure "Zelo" in the new position in one tide, and therefore "Zelo" might be caught without adequate moorings in the event of a sudden change of weather. The new plan was to adopt the chain cable spring moorings as permanent for the original position and to provide a complete set of supplementary moorings to be laid in any new position to hold "Zelo" until the

chain cable moorings could be lifted and relaid. A plan of the revised system of moorings is shown in Fig. 5, which shows the chain moorings in continuous lines, and the supplementary moorings in dotted lines. It was further decided that if bad weather was forecast both main and supplementary moorings could be laid out.

The "Ranger" remained at the case lifting the moorings which had dragged, and an indication of weather conditions is given in the following wireless messages received from her :—

8th July, 1939 : Moderate south-west gale and swell.
9th July, 1939 : Moderating.
10th July, 1939 : Similar.
11th July, 1939 : Moderate north-west wind and swell.

By continuous day and night work, "Zelo" was again ready, and proceeded to the case shortly before midnight on July 11th, but a forecast of westerly winds, force 5, delayed mooring, and on the 13th there was a strong south-west wind with no prospects of operations being resumed.

On July 14th weather conditions were still unsettled, with a bad north-westerly swell, and "Zelo" sheltered in Moelfre Bay.

On July 15th there were strong northerly winds, force 7.

Weather moderated during the night, and divers were able to descend during the low water slack period at 5 a.m. on July 16th. There was, however, considerable trouble and irritation by reeving wires becoming foul owing to the strong tidal currents, and it was not until the evening of July 18th that one lifting wire was placed in position under the propeller shafts of the submarine. At midnight a lifting wire was placed in position under the fore end of the keel, and at slack water on the morning of July 19th another lifting wire was rove at the selected position forward of the keel. By the afternoon of July 20th six lifting wires had been placed in position, and it then became necessary to lift the stern of the submarine in order to place the remaining two lifting wires in position.

On the early morning tide of July 21st the stern of the submarine was lifted smoothly off the ground and one 9in. wire was placed well below the keel ; but the reeving wire for heaving into position the remaining lifting wire fouled, and at 3.5 a.m. a wireless message was received from the salvage officer reading :—

"Will you concur our lifting with one wire below keel aft and three wires between keel and propellers ?"

Approval was given on the understanding that the three aftermost wires were placed as follows :—

One under the propeller shafts adjacent to the stern tube ;
One forward of the embrasure plates ; and
One at the point of junction of the after end of the keel with the hull.

On the midnight tide of July 21st a trial pin was made, and for that purpose all the wires were hove taut, and a test was carried out for the purpose of determining that each wire could be hove straight through from one side of the submarine to the other. The object of this test was precautionary to ensure that if during the course of a complete bodily lift any wire or series of wires carried away, such wires would reeve freely under the submarine and eliminate the risk of an unbalanced load coming upon one side only of the lifting craft. This test proved satisfactory. It was thereupon decided to make the first complete lift on the early morning tide of July 22nd, and at 7.15 p.m. on July 21st a start was made to take in slack wires, low water being at 9.40 p.m. Weather conditions at that time were ideal. At 1.30 a.m. on July 22nd, when, if all was well, the submarine should have been moving inshore, the author transmitted an inquiry to the Admiralty liaison officer at the case and received the following reply :—

"Regret to report there has been no victory stop In spite of excellent weather conditions severe strain possibly owing to light stern and heavy bows of 'Thetis' caused No. 7 and 6 beams to collapse in that sequence stop Consider you and Robb should come here to-day Saturday as soon as convenient, informing me time I should meet you at Llandudno stop Thomas [salvage officer] has seen this message and will not make his report pending your advices."

A conference was held on board "Hebe" in the afternoon of that day, and the following facts emerged :—

What was thought to be a perfect pin was made at low water, and all the wires were examined so that the load, as far as could be judged, was being evenly distributed over all the wires. Some adjustment was made to Nos. 1, 6, and 7 wires, numbering the wires in order from the forward end of "Zelo," and these wires were rendered up to approximately 18in., so as to secure uniform loading of all the wires. At that stage, which was about an hour after low water, all the wires were held, and our officer came to the conclusion that he had obtained a good pin down. For some reason the load on No. 5 wire did not increase at the same rate as the load on Nos. 6 and 7 wires, and the load on No. 8 wire became released altogether. Our officer did not know what load he had on No. 5 wire, but it seemed to have a fair load, although it did not show signs of serious straining as did Nos. 6 and 7 wires. As the tide rose, Nos. 6 and 7 athwartship beams began to show signs of twisting, and the fibres of the beams began to yield ; that is to say, the steel cruciform plates twisted, and some of the logs under compression "spat out" their fibre in the run of the grain.

Under those conditions the tackles holding the ends of the wires were continuously released by hand, and the wires rendered around the drum ends of the baulks in a series of very severe jerks. A stage was reached where it was not safe for men to try any further regulation of the load, and at that stage the tackles holding the ends of the wires carried away. Our officer was satisfied that the stern of the submarine was raised a considerable height from the ground, and that the bow was raised intermittently from the bottom, and its full weight was applied to baulks 6 and 7, with the result that the wires rendered until the bow again took the ground. These conditions were accompanied by the surging of the submarine ahead caused by the tide, and with each surge the bow made contact with the bottom, and during the momentary bearing of the full weight of the bow on the bottom and the resultant release of the load upon the wires, these wires slid in jerks up the inclined keel to a position further aft of the bow, *i.e.*, nearer to the centre of gravity of the submarine. Increase of the mean draught of "Zelo" showed that she was carrying a load of between 900 and 975 tons, which subsequently proved to be the total submerged weight of the submarine, and in our officer's opinion that load was borne as to about 75 per cent. by baulks Nos. 6 and 7, and as to the remaining 25 per cent. by baulks Nos. 1, 2, 3, and 4. The uneven loading of the after baulks on the "Zelo" was attributed to No. 8 wire being fouled, probably by a forward hydroplane. As the load increased it freed itself, and, in fact, streamed away towards the stern of the "Zelo," with the consequence that it exercised no restraint upon the tipping of the submarine at the bow. With regard to No. 5 wire, it was supposed that it either fouled small wire *débris* or was lying with a slight kink under the bottom, and when it became slack it was able to slip along the inclined keel towards the conning tower without taking any load.

As no means existed of retaining the lifting wires in their allotted positions, having regard to the strength of the tides and the impossibility of sending divers down to check the positions of the wires in the limited time available, it was decided there was no alternative but to consider replacing the existing lifting baulks on the "Zelo" with steel girders capable of withstanding concentrated loading such as was experienced on this occasion. It was agreed that it was impossible for divers to make surveys of each detail of the operations, and anyhow changes took place from one tide to another, with the result that information obtained by divers on one tide became valueless for the subsequent tide.

On these conclusions the following instructions were wirelessed to "Ranger" :—

"'Zelo' to withdraw Nos. 3, 4, 5, and 6 wires stop You to star and buoy with 30 fathoms buoy rope wires 1, 2, 7, and 8 stop North west and south-west mooring wires to be shackled together at eyes and buoyed together with 2½in. buoy ropes not more than 30 fathoms manilla stop Repeat exactly same procedure north-east and south-east moorings stop Recover easterly moorings stop 'Zelo' may then proceed Cammell Laird's basin."

(To be continued)

Precepts for Engineers*

DURING a period of forty-six years of practical work, and amid periods of depression, normal and prosperous times, I have had many experiences which I have endeavoured to translate into sixteen precepts. I give them to you for what they are worth. They are simple and you can make your own analysis of them.

Colleges have been criticised for not being more practical in their training. This criticism is not well founded ; colleges *are* concentrating upon these necessary essentials which cannot be learned effectively under the daily pressure of office or field work. Practice is one thing and theory another. Therefore I say :—

1. Start in the shop. Learn shop talk and shop language. After all, the work done in the shop is fundamental, and whatever your position may eventually be, a knowledge of that work is invaluable.

2. Take any kind of a job in adversity. If you cannot find the kind of a job you want, take what you can get. Ninety-nine jobs out of a hundred have opportunities concealed in them which an alert mind will find and develop.

3. At first salary is of secondary importance. When you have something to sell, command the price.

4. Try to select a job that will bring you in contact with the real boss.

5. If you find yourself in a rut—up a blind alley—don't be afraid to quit, but get another job first.

6. Wherever you live, carry your part of the community load—business, social and civic.

7. Never be a whistle quitter or beginner.

8. Look for and accept responsibility—never shirk it.

9. Look for the tough job the other fellow is afraid to touch.

10. Avoid discontent and jealousy. Build up your associate, don't pull him down.

11. Be honest in your opinions—not a "yes, yes" man. Do not be afraid to say "No."

12. Place principle above all else.

13. Never refrain from attempting a job because you fear defeat—never be afraid of fear.

14. Never be afraid to make a decision. No one always makes sound decisions. Those who maintain a high average are the captains of industry and our greatest leaders. I have observed that some of our greatest industrial captains are not college trained. Therefore it does not always follow that a college training is necessary in order to become an industrial captain.

15. Be a leader when you can as well as a loyal, devoted follower of a good leader. Loyalty combined with initiative can't be beat.

16. Be a booster for the company—build up, do not tear down.

* By Mr. Donald B. Gillies, Past-President, American Institute of Mining and Metallurgical Engineers.

Endurance is Skin Deep*

HAD the famous "one-hoss shay" lasted another nine centuries, it still would not have seen the service of an automobile's eight-year average life. Aeroplane engines have remained continuously in the air for as much as 650 hours, and in the largest of them the pistons sweep past 12 square feet of hot metal surfaces with each revolution—half an acre a minute ! A 60 H.P. V-8 engine must flash its pistons past a full newspaper page of cast iron with each turn of the motor ; and these figures take no account of journals, gear teeth, and other working surfaces.

That modern equipment meets increasingly severe demands, yet improves in reliability and endurance, is a tribute both to increased knowledge of forces and materials, and to advances in metallurgy, lubrication, and surface quality. In particular, minute changes in surfaces have significantly improved resistance to the combined abrasion, erosion, and corrosion we call wear. The difference between turning and lapping lies within a thousandth of an inch, yet a lapped gauge will outwear a ground one, and a ground surface will outwear the usual turned one, as the Germans dramatically demonstrated during the World War. By grinding all critical surfaces in their Diesel engines, they gave U boats a range and freedom from breakdowns which amazed and disheartened Allied commanders. The effectiveness of wholesale grinding in improving the performance of the higher compression internal combustion engines accelerated its spread to other fields, among them locomotives and automobile engines ; and it was mainly the tremendous demands of the latter industry which forced the development of other machinery for producing highly accurate surfaces on a mass scale. The ability of a present-day owner to drive his new car away from the sales room at the same speed he approached it in his old one is an indication of improved surface quality. His increased freedom from lubrication troubles and overhauls is in part another.

Although improvements in finish are accompanied by reduced initial wear and slower wearing final surfaces, continued progress towards smoother surfaces may increase the dangers of insufficient clearances for oil films, and of seizure. Highly finished surfaces, for instance, give tighter press fits. It is easily possible to scrape a smooth glass plate clean of liquid, but not a sheet of frosted glass, where innumerable hollows act as tiny reservoirs that a squeegee cannot touch. Similarly, in a recent process, constituents of a smooth steel surface are selectively removed by chemical action to form an irregular mesh of tiny grooves and pits. Enough remains of the surface to create an even bearing area, but space is also provided for storing oil, thus reducing break-in time and increasing the load-carrying capacity of bearing areas. On the other hand, where proper lubrication can be maintained between dead smooth surfaces they appear practically immune to wear.

Less obvious is the effect of surface quality on fatigue strength, that is, the strength of materials under repeated, fluctuating stresses. Stresses concentrate at discontinuities ; as Professor A. V. de Forest puts it, they "accumulate in corners like dirt." A diamond scratch one thousandth inch deep can lower the fatigue and impact strength of a glass specimen to as little as one-hundredth part of its former value. With a more ductile material like steel, a single scratch on a polished surface can

* From the *Industrial Bulletin*, May, 1940.

reduce fatigue strength by 20 per cent. Springs retaining the original, hot-rolled surface may possess but half the fatigue strength they have when ground, and on other machine parts surface irregularities caused by machining and exposure to reactive furnace atmospheres can have a greater effect on properties than heat treatment or minor variations in compositions.

Even corrosion is inhibited by sheer mechanical perfection of surface, for although corrosion can start at inclusions in the smoothest of surfaces, it is apparently favoured by sharp notches. It may also be noted that fatigue strength is seriously and adversely affected by even mild corrosion.

The general use of highly refined surfaces is strictly a twentieth century phenomenon. Hand lapping and scraping are both older than the machine tool industry, but both are also too costly for all but special applications. Not until the grinding machine stepped into the production line in the early 1900's was there available a means for the large-scale manufacture of precision surfaces. Even a ground surface, however, ordinarily shows grooves and undulations coarse enough to prevent the use of the optical flat and interference light bands as a means of measurement, an effective obstacle to utmost accuracy in dimensions.

To-day, mass production of quality surfaces is possible by methods ranging from honing to shot blasting, the latter method being used on clutch discs, springs, and rear axle shafts to hammer out surface imperfections and lengthen life. With diamond and metal carbide tools at high speeds and fine feeds, even turned surfaces are excellent.

Attention has also centred recently on the "super-finish" from abrasives slowly and lightly rubbed over a machined area in the presence of a lubricating and cooling fluid. Compared with grinding speeds of 5000ft. per minute, grinding pressures of 50 lb. to 100 lb. per square inch, and surface temperatures that run to 800 deg. Fah., super-finishing raises the temperature scarcely a degree, runs the abrasive at less than 10ft. per minute, and keeps pressure between work and abrasive at a few pounds or less. Nevertheless, the time required to finish a piece is measured in seconds, for only enough material is removed to get below the ridges and high spots of previous machining operations. Somewhat self-controlled in operation, super-finishing erodes the high points until they are flat enough to support a film of oil, which prevents further removal of metal. The scratches which remain serve in use as reservoirs for oil. Irregularities on super-finished surfaces can be maintained at less than ten-millionths of an inch.

Newcomen Society Summer Meeting

THE Summer Meeting this year, June 13th and 14th, was shorn of much of its interest; in fact, it bid fair to be dissolved altogether by the turn of events subsequent to the decision to hold it, and that decision was for a meeting on a reduced scale. The London area for the fourth time was the venue—the Wandle Valley, that hive of industry since the sixteenth century, owing to its constant water supply and the quick fall in its short course, was chosen for the first day's visit. The start was made at the Institution of Mechanical Engineers, Storey's Gate, and the route taken was by Chelsea Embankment to Wandsworth Bridge, where a peep can be obtained of the mouth of the Wandle, where existed the terminus and the wet dock of the Surrey Iron Railway, completed 1803, the first public railway in the world, for earlier plateways had been reserved by their owners for their own use. The dock is on the premises of the Wandsworth Gas Company, and it is now being filled in; with it goes the last important trace of the railway. Wandsworth Bridge being closed, the Thames had to be crossed at Putney. Returning thence to Wandsworth, the coach continued by Buckholt Road and followed roughly the course of the Wandle to Merton and thence to Mitcham Clock Tower. The route followed was by Beddington Lane and a pause was made at the level crossing where the present Southern Railway single line crosses the road, for from there the longest portion of the track, now covered by the branch from Wimbledon to Croydon, can be seen.

Continuing to Carshalton where is the source of the Wandle, the party arrived at the Grove Works of Messrs. John Smith and Co. The works have a long history, going back to the seventeenth century, but what they were used for then we do not know. During the Napoleonic Wars they were used for boring cannon and later the premises were occupied as a snuff mill. A note on the history of the mill so far as known was distributed. The principal item of interest shown to the party by Mr. F. C. Nunn, the proprietor, was the only overshot water wheel to be found in the course of the Wandle. An embanked canal, constructed in 1715–20 by Sir William Scawen (1647–1722), Lord of the Manor and thrice M.P. for Surrey, brings water from springs in Carshalton Park to the Grove Works. The wheel is 20ft. 6in. diameter by 5ft. 9in. wide, and is of timber construction. The supply of water runs short in summer; hence a steam engine, of the grasshopper or half-beam type, familiar enough when installed about a century ago, is coupled up to the millwork to take on the load. This engine has a cylinder 10½in. diameter by 19in. stroke, and runs at about 65 r.p.m. Nor is this all, for there is also a gas engine to run the works. Thus the members had in front of them examples of three periods of power production. Another object of interest in the grounds was the stone bed of an edge runner mill, 5½ft. diameter, with two edge runners 3½ft. diameter, for grinding snuff. The objects had been brought from Hackbridge. At the gate also was to be seen a pyramid of stone sleepers from the Surrey Iron Railway. A branch from Hackbridge extended thus far.

After lunch at the White Hart Hotel, Mitcham Green, the afternoon was devoted to Greenwich. *En route*, at West Croydon Station the site of the terminus of the Surrey Iron Railway, the site of the basin of the Croydon Canal, and the site of the terminus of the Croydon Atmospheric Railway were visited. Further on, at Anerley, the only remaining portion of the Canal, in water, was seen. At the National Maritime Museum at Greenwich the party was hospitably received in the Library by Sir Geoffrey Callender, the Director, and was shown many interesting objects, which, in spite of war conditions, can still be exhibited. The object that attracted most attention was the model by Sir Christopher Wren of the cupola of the Hospital, recently discovered by Sir Geoffrey and reconditioned. The Brunel-Maudslay block-making machinery models were also seen. The return to town was made after tea.

On Friday, June 14th, the party met at the workshops of Francis Higgins and Son, Ltd., 9, Newman Street, W., by kind permission of the firm. This is one of the very few firms that carry on the making of silver tableware as a pure handicraft. An exhibit of replicas of such ware from the fifteenth century to the present day was displayed, and it is interesting to know that any one of these designs can be repeated. The whole process from the hot forging of the blank from the rolled bar to the filing and polishing was seen. Where embossing is called for, this is effected by steel dies in a fly press—one of the largest we have seen, 11ft. centre to centre of the balls, which are 20in. diameter.

The next visit was to the bedding and mattress factory of Messrs. W. and C. Nightingale, 70, Old Street, E.C. Here a compound beam engine of about 1850 was seen. The H.P. cylinder is 16in. diameter, 2ft. 9½in. stroke, and the L.P. cylinder 24in. diameter by 4ft. stroke. An indicator diagram showed that the H.P. cylinder had developed 21 H.P. and the L.P. cylinder 19·7 H.P. at 58 lb. pressure and 34 revolutions. Some cast iron floor beams, marked "Dewer 1837," were also seen.

After luncheon, the party drove to New Barnet to visit the Abbey Folk Park, where they were welcomed by the Director, Father J. S. M. Ward. This is an open-air Folk Museum, the only one of its kind so far in this country and similar to that at Skansen, in Norway. It embraces reproductions of huts from the paleolithic age onwards, entire houses, old-time workshops, &c., each complete with furnishing and tools of the period. There was not time to see more than a tithe of the exhibits, and the ethnological section had to be missed altogether. After tea in the open air amid silvan surroundings, a return was made to town. The weather, as has been so frequently the case in Newcomen meetings, was sunny and temperate, and those who took part greatly enjoyed the break from ordinary duties.

American Engineering News

Belt Conveyor for Shasta Dam

To convey screened and washed aggregate from the washing plant to the concreting works at the Shasta Dam in California, a distance of approximately 10 miles, the contractors have put in service a belt conveyor system in 26 flights or sections, each of 23 sections driven by a 300 H.P. electric motor. About 10,500,000 gross tons of aggregate will be furnished by the United States Government. For most of the distance the conveyors are a few feet above the ground, the trough rollers and return rollers being mounted on low wooden frames. Near the washing and sizing plant, however, it is carried at a higher elevation by steel towers, and similar towers 100ft. high carry the supporting structure across a ravine. The belt line crosses two rivers, four smaller streams, a railroad and six highways. Three sections on a descending gradient of 1 in 4 are equipped with motor-generator units which can utilise the potential energy of the loaded descending belt to generate power for assisting to pull the belt up the other side of the valley. The entire system, operating day and night, is illuminated by sodium vapour lamps. It is estimated that for the concreting programme of the dam the conveyor system must supply daily about 16,000 tons of gravel, and 6000 tons of sand. Its normal capacity is 1200 tons per hour at a belt speed of 550ft. per minute, or about 1¾ hours for transit from the washing plant to the storage bins of the concreting plant. At the end of each section is a steel trough or chute feeding the material to the next section. When complete there will be about 20 miles of 36in. three-ply rubber belt. Starting at 490ft. above sea level, the conveyor system rises to 1450ft. at a mountain pass and delivers to the bins of the concreting plant at an elevation of 650ft. It is estimated that the concreting of the dam will take about four years to complete.

Storage of Volatile Liquids

Extended research in the American oil refining industry has resulted in the production of more volatile and more efficient grades of petrol or gasoline, but with it has come a problem in methods of storage which will prevent the loss of the light hydrocarbons by evaporation. Numerous devices have been developed for this purpose, some of which have been adopted for general use. Manufacturers of storage tanks have produced effective vapour-tight tanks. To maintain lower and uniform temperatures of tanks, the use of light colour paint is common practice, with water cooling systems in occasional use, and wider use of spray on tank roofs. Insulation and sun-shading are rarely used, owing to the high cost. The "breathing" roof provides a vapour space which varies with the change in volume of the air-vapour mixture in the tanks so that vapour is retained and not forced into the atmosphere. The vapour-tight roof is a flexible diaphragm attached to the tank shell and normally resting on interior supports, but free to lift or "breathe" with expansion of the vapour. In the balloon roof, the flat roof itself extends beyond the tank shell and varies from saucer shape to dome shape. A modification is the piston balloon which slides within the tank shell and is counterweighted to keep the operating pressure at a small fraction of an inch of water. For large tanks, up to 350,000 cubic feet capacity, the balloon consists of two flexible diaphragms connected by a short vertical shell. Another method of reducing evaporation loss is to use gas-tight containers capable of resisting the maximum internal pressure. Tanks of cylindrical, spheroidal, and spherical shape are used for this purpose, in sizes up to 12,000 barrels capacity, especially at industrial plants using butane and propane gases for fuel. In the spheroidal tank for a capacity of 100,000 barrels, with internal pressure of 2 to 15 lb. per square inch, the height is 75ft. and the maximum horizontal diameter is 100ft., or 40ft. by 132ft. in order to reduce the height. Spherical tanks are made up to 20,000 barrels capacity.

Coal Research Studies

In the extensive coal research programme of the American Institute of Mining and Metallurgical Engineers, there has been much use of the moving-picture camera for studying the actual conditions of combustion. Ordinary "movie" cameras may be used for short exposures. But for many purposes, especially where long exposure to intense heat is required, a pyroscope may be fitted to the furnace. This instrument consists of two telescopes end to end in a water-cooled tube, so that the camera is kept away from the furnace heat, and pictures can be taken through small holes. Motion in the coal bed of a mechanical stoker may be recorded by pictures taken at 3-second intervals, and then projected on the screen at the rate of 16 per second. This speeds up the actually slow process, and makes the feeding and agitation clearly visible. Or by speeding up the rate of taking pictures there is obtainable the "slow-motion" effect, which is very useful for watching the travel of flame in pulverised-coal furnaces. Moving pictures have been taken to show flame travel, slag formation, and slag tapping in a 75,000 lb. per hour pulverised-coal boiler. In one case, the fire door of a small domestic heating stoker-furnace was replaced with a sheet of fireproof glass, through which views were taken to show the action of the stoker and the fire. Similar work has been done to show the combustion process with various types of furnace burners for oil and gas. For burning pulverised anthracite, it is usually fired directly into water-cooled furnaces, with preheated air at high-temperature. Vertical firing is found to give the best results, with long flame travel and a mixture much richer at the burner than when bituminous coal is used. However, stokers of the spreader type can burn the small sizes without pulverising, while single-retort underfeed stokers can burn all but the very small sizes. Special study is being made of the viscosity of coal-ash slags, using a viscosimeter suitable for temperatures up to 2900 deg. Fah., to give information as to the clinkering and fusion characteristics of such slags.

COKE OVEN GAS SUPPLY FOR GLASGOW.—After discussion which has gone on for a period of almost three years, the Corporation of Glasgow has decided to accept the offer of William Dixon, Ltd., of Govan Ironworks, Glasgow, to supply coke oven gas to the city. It is understood that a three years' contract has been arranged for a supply of 5,000,000 cubic feet of gas per day. The scheme, which has been approved by the Mines Department, will necessitate the construction of a new pipe line connecting the coke oven plant at the Govan Ironworks with the Tradeston Gasworks, at an estimated cost of about £13,000.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

Exporters' Risks in War Time

The Export Credits Guarantee Department has issued a small booklet with the above title. It shows how a firm may safeguard its export trade with a Government guarantee. It is the function of the Export Credits Guarantee Department to minimise the risks of export trade in war time. Since the launching of the national drive for export the Department has put into operation special facilities to help traders to meet the war situation. It gives exporters protection against these risks on favourable terms. A comprehensive guarantee ensures that an exporter, in the event of his customer's insolvency, will receive 75 per cent. of the debt guaranteed, whether on bill or open account, plus a further 25 per cent. of all recoveries effected from the debtor's estate. Practically every market with which he trades can be included under this type of policy, which covers shipments for a period of twelve months at a time. Premium on a comprehensive policy is fixed at a flat-rate percentage over the whole policy, and naturally varies according to the countries covered and the degree of risk in those countries. For a supplementary premium the holder of a comprehensive guarantee policy is able not only to protect himself against loss or delay due to the operation of exchange restrictions, but also against the special risks of transfer arising from war conditions. Any individual country may be selected by the exporter for this additional cover, which is given by way of an addendum to the comprehensive guarantee policy. This addendum expressly covers the risk that payment may be prevented by the occurrence of war between the buyer's country and the United Kingdom, or by war, civil commotion, or other disturbances in the buyer's country. The proportion of risk carried by the Department is, with few exceptions, as high as 90 per cent. Special arrangements provide that the exporter will not be prevented from making his claim if war conditions make it impossible for him to prove that the general conditions of the policy and addendum have been fulfilled. For example, where he is unable to prove delivery of goods to a buyer owing to war or other similar occurrence, the addendum provides for assumption of liability by the Department if it can be shown that the goods have reached the buyer's country. The transfer addendum also provides cover on amounts in excess of the maximum credit limit agreed for the buyer, provided that the latter has made an irrevocable deposit of local currency with an approved bank for any sum in excess of such limit. Debts expressed in certain foreign currencies can also be included in the cover. Other improvements and simplifications of the transfer cover available before the war have been introduced, all of them with the object of making it easier for the exporter to ensure his risks with the Department, and of extending the facilities available to him. Wartime hindrances to imports may prevent an exporter from shipping goods which have been ordered, and perhaps specially manufactured. To meet this risk the Department offers, either as a supplement to the Comprehensive Guarantee or as a separate policy, insurance against the risk that loss may arise through the inability of the exporter to ship owing to insolvency of the buyer, or the imposition of import regulations, or invasion, or war.

The Steel Distribution Scheme

The following notice has been issued by the Ministry of Supply, Iron and Steel Control :—It has been observed from the returns made that a substantial number of orders still on the books of finished steel producers remain unsymbolised, and it is considered by the Control that sufficient time has been given to all contractors to enable them to obtain the necessary authority from the Departments concerned to use the symbol, reference number, and period numbers in respect of each order placed with finished steel producers. The finished steel producers have therefore been advised that if they do not receive the symbol, reference and contract numbers with reference to the orders which they have on their books by June 15th, 1940, it is proposed to regard these orders as cancelled. It is essential, therefore, that all firms who have not taken steps to obtain the necessary authority from the Government Departments should do so at once.

The Pig Iron Market

In spite of the increased demand, deliveries to consumers engaged upon war work are well maintained; but there does not seem to be any surplus when these requirements are met. The demand for foundry iron, which, for some time, has been restricted, has improved to some extent as more of the light castings establishments have been brought into the war effort. Although there is no stringency in the foundry iron position it appears tighter than for some time previously as a number of the furnaces have been turned over to the production of basic iron. Enough high-phosphoric foundry iron is being manufactured to meet the requirements of users, but were the demand to expand as a result of more of this iron being required for munition purposes it is possible that a stringency might develop. Even at the present time licences are being carefully scrutinised, and it is almost impossible to obtain supplies for any purpose not associated with the munitions drive. The shortage of low-phosphoric foundry iron is more noticeable of late, and as a result consumers are turning to a greater extent to the use of hematite. Engineering firms and others engaged upon munitions work are eager buyers of this description, and it is hoped that reports that the production is to be increased have a sound foundation. The demand for hematite iron also has considerably expanded as a result of the munitions drive, and consumption is now well in excess of the production. The makers, however, still have a certain amount of iron in their yards, and by using these stocks sparingly deliveries have been maintained to consumers. The proportion of the output of hematite iron which comes on the open market is not large as most of it is used by associated works, particularly on the North-East Coast. The Control is taking great care, in arranging the distribution of this iron, that consumers engaged on national work do not go short. There is little chance, however, of any iron being liberated for purposes unconnected with the war. Considering the extraordinarily heavy demand for basic iron it is surprising how well the supplies to the steel works are being maintained. The pressure to get deliveries is intense, but raw materials seem to be in better supply than at any time during the war. The scrap situation, for instance, has greatly improved, partly as the result of the intensive effort to obtain home supplies and partly through substantial imports from abroad.

The North-East Coast and Yorkshire

Under the new scheme of working a seven-day week record outputs are being obtained by the North-East Coast steel works. Supplies of steel have, therefore, improved, partly because of the greatly increased flow of domestic scrap. These collections are augmented by large imports and for the time being the scrap situation does not occasion anxiety. Naturally, there is some apprehension as to the effect upon the re-rolling industry of the loss of supplies of Continental billets, but it is believed that arrangements which have been made to obtain this material from other sources will fill the gap. The production of billets by the British integrated plants is large, but the increased requirements of the associated rolling mills are so great that there is not enough left to meet the needs of the re-rollers. All the shipyards on the North-East Coast are fully employed and their requirements are exceptionally heavy, although it is understood that production has reached a figure which permits a certain amount of steel to be diverted to other essential purposes. The plate mills, although they are operating at capacity, are finding it impossible to meet the demand in full. This class of steel enters into the manufacture of so many important products needed by the Services that practically the whole of the output is taken for urgent Government requirements. The locomotive builders are also fully occupied, whilst the tank makers have enough work in hand to keep them busy for months. The call for plates covers all thicknesses, although probably the demand is rather heavier for the larger sizes. The sheet makers have been busy for months and continue to turn out large quantities for Government purposes, and their output is only limited by the supplies of raw materials in the shape of sheet bars. In some districts a stringency has been noticeable for some time in this department, but it is hoped that arrangements made by the industry will overcome the difficulty. The Yorkshire industry has thrown its full weight into the munitions drive, and production is said to be upon an unprecedented scale. At the Sheffield works the output of basic billets is exceptionally large, and is immediately absorbed, whilst there is an active demand which cannot be entirely filled for acid carbon billets. The demand for alloy and special steels has expanded enormously since the munitions drive, and the Sheffield works are supplying large tonnages of aircraft steel and steel for use in Army motorised equipment.

The Midlands and South Wales

Like all other steel-producing districts, the works in the Midlands are concentrating upon increasing production to meet the requirements of the munitions drive. There has been a considerable expansion in output and the consuming industries are working at an unprecedented rate. Supplies of all kinds of steel are urgently needed and great efforts are being made to meet the demand. The Control is carefully watching the situation and works managers get instructions almost daily as to the priority of the work in hand. There is no doubt that the execution of a large tonnage of orders will be delayed until more urgent national work is completed. It is certain that much of the work now on the books will be carried over until the third quarter, and it is obvious that the present situation has thrown a great strain upon the recently introduced distribution scheme. There has been some speculation as to the possibility of a review of prices at the end of June, but it is not anticipated that any change will be made until the pressure of present conditions has to some degree abated. A satisfactory feature of the situation is that in spite of the loss of supplies of semi-finished steel from Belgium and Luxemburg the production of the re-rolling works has not so far suffered. Considerable arrivals are expected from the United States, and it is hoped that these will reach this country in time to avoid any restriction of output by the finishing works. The demand for joists, bars, and sections is unrelaxed, but it is hoped that the employment of inspectors to watch for and prevent any waste in the use of steel will have the effect of conserving some material. The finished ironworks are now operating at capacity and the tonnage on the makers' books ensures employment for several months. In some cases the works are extending their delivery dates, but most of the iron-masters are able to quote for fairly near delivery as compared with the times required for steel. The activity at the steel works in South Wales has increased as a result of the munitions drive, and practically the whole output of the district is now passing into use for Government purposes. The production of steel is on a much higher scale as a result of better supplies of raw material, including scrap. In May the production averaged 29,880 tons per week, compared with 25,231 tons in April; but was less than the output in May, 1939, of 31,055 tons per week. The tin-plate market is less active than a few weeks ago, and overseas buyers are less pressing in their demands. The latest figures for the industry, however, show that it was employed at 70·82 per cent. of capacity. Export prices stand at 30s. to 31s. f.o.b. Welsh ports, whilst the home trade price is fixed at 24s. 9d. f.o.t., 20 by 14 basis.

Copper and Tin

World events are naturally exercising a great influence upon the copper market. Although contracts for considerable quantities which would have been shipped to Italy and Russia have been cancelled, the new attitude of the United States towards the Allies is likely to more than make up for the loss of the Italian demand, since it may be expected that greater quantities will be shipped to Great Britain and France. The consumption by Great Britain must be upon an enormous scale, and is not likely to decrease for a long time to come. America's own rearmament programme also will absorb huge tonnages of the metal. In spite of the loss of many European markets the price in the United States has strengthened and now seems firm at 11·50c., both for domestic and export. Home buying has been active and is placed at between 70,000 and 80,000 tons for the first half of June. The inference is that American consumers anticipate a big war demand and are doing their best to cover their commercial requirements. According to American statistics the stocks at the end of May totalled 178,664 short tons, an increase of 9544 tons. The production of refined copper in May reached 86,607 tons, a rise of 5643 tons compared with April. In Great Britain the position remains unaltered. All the copper required by firms executing national contracts is forthcoming, and there are indications that there is no stringency in the position. . . . Following the entry of Italy into the war American consumers bought tin heavily in the expectation probably that there might be some interruption to supplies. This affected the London market and there was a sharp rise in prices. American buying was on a somewhat reckless scale and heavy purchases were made both in London and in the East. The French Government also bought and English consumers entered the market when prices began to rise. British consumption is evidently at a good rate and there is a tendency for users to endeavour to lay in stocks. It is interesting to note that for the first time for several weeks the backwardation in the market disappeared and a contango developed. It has been the view of a section of the market for some time that in the existing conditions a contango should rule. Whilst there is an inclination to regard the present price as at a rather dangerously high level there seems no reason why there should have been any recession since buying continues active. On June 19th the liquidation of speculative positions caused a fall in prices of about £21 7s. 6d. Later the price rallied, and on balance the decline was about £12. It has been decided by the Committee of the London Metal Exchange to allow dealings without restrictions, although the question of minimum and maximum prices has been discussed.

Lead and Spelter

Conditions in the lead market in Great Britain are satisfactory, and supplies of lead appear to be reaching this country with regularity and in sufficient volume to meet the exceptionally heavy demand. The diversion of shipping from the Mediterranean a short time ago has largely removed the risk of interruption by hostile action, although, of course, there is a danger that Italian submarines or ships may escape into the Atlantic and temporarily interrupt the routes from Australia, Burma and Mexico. The supplies of lead which Italy imported came chiefly from Mexico and this source is now cut off. The quantities that Italy received in this way, however, were not large. Consumption in Great Britain is at a high level and has increased as a result of the munitions drive. In the United States the market is fairly active and consumers appear to be building up reserves. The quotation, however, remains unaltered at 5c., New York. . . . The consumption of spelter in Great Britain appears to be increasing and is almost entirely for war purposes. There is a big demand for high-grade metal, but in most cases consumers who would prefer to have ordinary G.O.B. spelter are obliged to take the higher quality. In the United States there have been substantial purchases by the Allied Purchasing Commission. Probably a good proportion of this was for France, who has now lost for the time being most of the works from which she drew her supplies. It is understood, however, that Great Britain has taken over the French commitments. In addition to the Allies, India has bought with some freedom and Japan also has been in the market. In Great Britain the galvanising industry continues to take considerable quantities, although the rationing of the industry by the Steel Control may have caused a curtailment in some of its requirements. The die castings makers are also busy, whilst the brassmakers are taking larger quantities than ever as a consequence of the munitions drive.

FORD TO MAKE ROLLS-ROYCE AERO-ENGINES.—The Minister of Aircraft Production announces that a contract has been placed with the Ford Motor Company, of Detroit, for the manufacture of 6000 Rolls-Royce Merlin engines. Production will begin in a month and deliveries will start early next year.

CUTTING A WATER PIPE IN SERVICE.—An abstract in *Engineering News-Record* describes a method adopted to move a 1in. service water pipe which was connected to an 8in. main laid under a main street without breaking the pavement or shutting down the main line. Several thicknesses of paper were placed under the 1in. pipe, and then about 1 lb. of dry ice was packed round the pipe. In about 10 minutes the pipe was frozen solid and it was then cut and the new section, with a meter and stop cock, connected up to it. The ice was then uncovered and water poured on the frozen section of the pipe until the meter began to register. The entire operation was carried out in about half an hour, with a minimum of work, expense and inconvenience.

Canadian Railway Operation in the Winter

PROVIDING Canadians with uninterrupted coast-to-coast train service in the worst winter weather is no inconsiderable undertaking. The tracks of the Dominion's great railway systems are cleared of the obstructing forces of nature by an amazing collection of snow-removing equipment operated by an army of trained snow fighters spread out across the country. The total mileage of rails equals the distance twice around the world, and snow and ice may be encountered on any foot of the way.

The most formidable unit in the snow-fighting equipment is the huge rotary snowplough, built to battle with anything from a record snowslide to a mountain of snow and ice. Weighing approximately 130 tons, some of these powerful machines are almost 50ft. long. Set on two six-wheeled bogie trucks, these juggernauts push a 12-ton scoop wheel which revolves at 400 r.p.m. and does its best work in mountainous regions. On the steep mountain grades the battle between railwaymen and the forces of nature is dramatic and exciting. Occasionally one sees four or five huge locomotives pushing a rotary through a mountainous snowdrift with the plough completely out of sight and its presence betrayed only by the fountain of snow it spouts from its path. After the struggle between steel and snow has ended, a deep square-cut trench through the white wall reveals the hidden steel rails and a patch of sufficient width for the trans-continental express to speed through on schedule.

When blinding blizzards, driving rains or spring fogs practically deprive the locomotive engineer of his sense of sight, both sound and smell come to his aid. His battle against the elements is made easier by the use of a fog signal which not only explodes with a flash of light but gives off a pungent odour. When it is impossible to signal the engineer with lantern, torch or flag, the operating crew resorts to this "track torpedo." If the howling wind and blinding storm prevent the engine crew from hearing the report or seeing the flash they can smell the powerful concentrated chemical released under the locomotive's wheels.

The railroader's fight against winter conditions is also made easier by another signal device in the brakeman's flagging kit. Red and yellow emergency flares, known to railroaders as "railway fuses," do an important signal duty. Shaped somewhat like roman candles or large firecrackers, these torches are placed on the engineer's side of the track and are used to convey a variety of signals to the man at the throttle. These emergency flares burn for various intervals in all weather conditions. A metal spike in one end allows these torches, which are used in conjunction with the brakeman's signal flags and lanterns, to be tossed from a moving train into the road-bed to warn following trains of possible danger.

This battle against winter conditions extends right down to the loads carried in freight cars. When such materials as ore, gravel, coal and sand freeze their unloading is facilitated through the use of dynamite. In the hopper cars, which are unloaded from the bottom, freezing generally occurs in the chutes. The hopper doors are swung open, a hole punched in the load and a small blasting charge inserted to break up the materials for easy handling. Blasting is also resorted to by the snow crews when a snowdrift is frozen solid or an ice blockade impedes railway traffic.

Vestibuled cabs with heavy snow-curtains bring complete winter protection to the engineer and his crew on both snowploughs and regular locomotives, whilst the familiar centrifugal wind screen throws off ice, sleet and snow to give the man in the engine a clear view of the track ahead even through the severest of winter conditions.

Among the worst conditions the railroads' operating crews face are sleet storms and heavy snowfalls followed by rain and severe frost, which leave rolling stock and tracks covered with slippery films of ice. At such times salt supplies distributed before winter sets in do their duty in freeing switches and other sections of the line from the paralysing grip of ice.

POWDER METALLURGY AND GEAR MANUFACTURE.—An abstract in the *Journal* of the Institution of Automobile Engineers gives particulars of some oil pump gears which are being made by the Moraine Products Division of the General Motors Corporation by porous powder metallurgy. The gears are formed in finely polished precision steel moulds using a Swedish iron powder sintered at 1093 deg. Cent. Each finished gear is true to the specified dimensional tolerances of about ±0·001in., the tooth form requiring no finish machining. Final machining operations are limited to chamfering and drilling, grinding the ends to exact length, grinding the outside diameter, and burnishing the bore. Perfectly formed involutes can be formed without undercut by this method. The material used, known as "Durex iron," has a tensile strength of 20,000–25,000 lb. per square inch, and a relative density of but 75 per cent. of a corresponding cast iron gear. The structure, after sintering, may be likened to that of high-carbon steel, but, owing to its porosity, the material has self-lubricating properties and excellent wear resistance and gives quiet running.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

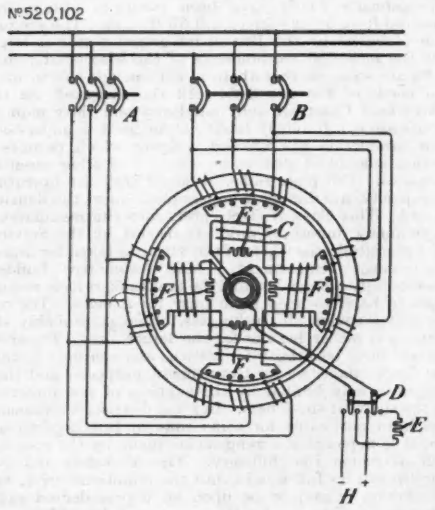
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

DYNAMOS AND MOTORS

520,102. October 26th, 1938.—DYNAMO ELECTRIC MACHINES, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2.

The object of this invention is to provide arrangements for protecting the secondary winding of a polyphase synchronous motor when only a concentrated portion of its armature winding is energised and the motor is operating at a subsynchronous speed. The motor is started by closing one of the switching means A B so that only one group of armature windings is energised to start the motor from rest. After the motor has reached a predetermined speed, the other switching means is then operated so that both groups of armature winding are energised during the normal operation of the motor. In order to limit to a safe value the voltage across the field magnet windings C when only one of the two groups of armature windings is energised and the switch D is in its position in which the resistor E is connected across the collector rings a resistance F is also

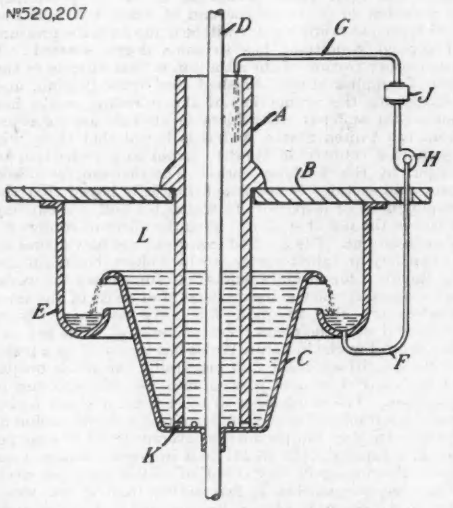


connected across each of the field windings. These four resistors are preferably mounted on the rotor in any suitable manner and are designed so that they have impedance values which are relatively low. While the motor is operating with only one group of armature windings, it is obvious that as the rotor rotates two of the field magnet windings are in close coupling with the energised group of armature windings at any given instant and the remaining two field magnet windings are not and that the two windings that are in close coupling periodically change. Since all of the windings are connected in series and the impedances of the windings are high with respect to the discharge resistor, it is evident that if it were not for the shunt resistors, a very high voltage would be built up across the windings which might result in a breakdown in the insulation. After the motor reaches a predetermined speed, the other group of armature windings is connected to the source and the switch D is moved to its other position so that the source of excitation H is connected across the brushes.—*April 14th*, 1940.

ELECTRICAL APPLIANCES

520,207. October 21st, 1938.—LEADING-IN INSULATORS FOR HIGH TENSION CURRENT, *Lodge-Cottrell, Ltd., of George Street (Parade), Birmingham.*

This invention relates to leading-in insulators for high tension current, and especially to leading-in insulators for use in apparatus for the electrical precipitation of suspended particles

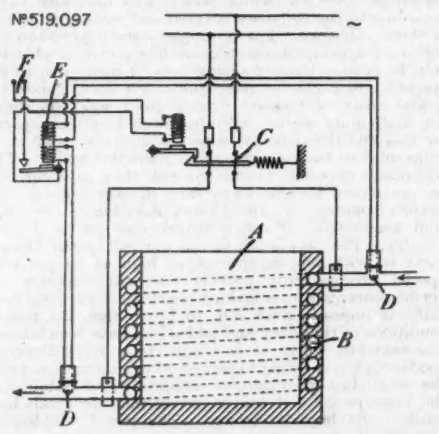


from gaseous fluids and described as "electrofilters." In the example shown a leading-in insulator A rests by a collar on the top B of the electrofilter chamber. To the insulator A is attached a funnel-shaped vessel C filled with oil or other insulating liquid. A conductor member D is provided which may at the same time support the discharge electrode system. Depending from the top B of the chamber is arranged an annular trough E which serves to prevent the dirty gases in the chamber from coming into direct contact with the insulator and serves also to collect the oil overflow from the vessel C. The oil can be kept in circulation through pipes F and G by means of a pump H, and may be purified and heated if required in a vessel J. The oil drops down inside the insulator and reaches the funnel-shaped vessel C through openings K at the bottom of the leading-in insulator A. The chamber L formed by the trough E is protected against the entry of dirty gases by a film of oil which flows over the lip of the vessel C into the trough E.—*April 17th* 1940.

FURNACES

519,097. October 27th, 1938.—IMPROVEMENTS IN HIGH FREQUENCY ELECTRIC INDUCTION MELTING FURNACES, Kohle und Eisenforschung, G.m.b.H., 28, Ludwig Knickmann Strasse, Düsseldorf, Germany.

A high frequency induction melting furnace A has embedded in its wall a tubular induction coil B through which cooling water flows. The induction coil is connected through fuses to the main switch C. Thermo elements D are disposed in the coil at the outlet and inlet for the water and are differentially connected to excite a relay E when a pre-determined difference in the temperatures of the cooling water at the inlet and outlet has been exceeded. The operation of the relay is thus rendered independent of temperature fluctuations of the cooling water at the inlet. The relay when excited, closes an



auxiliary amplifying circuit F for the purpose of cutting out the switch controlling the supply of current to the coil. If desired, an indicating instrument may be employed instead of the relay, and it would be provided with limit contacts for closing the amplifying circuit. The use of such an instrument has the advantage over the use of a relay that the difference in the temperatures of the cooling water at the outlet and inlet may be read off at any moment. Thus, the formation of a break in the furnace wall may be observed at the start and the switch cut out before any considerable damage is done, whilst with the use of the relay it may happen that the supply of current to the coil is not cut out until the metal breaking through the furnace wall has come very close to the coil.—*March 15th*, 1940.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institution of Civil Engineers

Wednesdays, June 26th and July 3rd.—N.W. ASSOC.: College of Technology, Manchester. "Recent Developments in Air Raid Precautions," R. E. Bowles. 6.30 p.m.

Societe des Ingenieurs Civils de France

Tuesday, June 25th.—Institution of Civil Engineers, Great George Street, S.W.1. "Recent Developments of Pre-stressed Concrete Construction with Resulting Economy in the Use of Steel," K. W. Mautner. 5.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

Mr. W. A. TOOKEY, M. Inst. C.E., M.I. Mech. E., M.I.A.E., has changed his address to 83, Cumberland Road, Bromley, Kent.

J. H. FENNER AND CO., Ltd., announce that their "V" rope sales department is now situated at their Heckmondwike, Yorkshire, Works.

MR. J. TATLOW, who has been works manager, Riley (Coventry), Ltd., since 1938, has been appointed general manager of that company.

THE CARBORUNDUM COMPANY, Ltd., Trafford Park, Manchester, has appointed Mr. R. Douglas Robin as its representative in the Glasgow and South-West Scotland area, in succession to the late Mr. Gordon D. Hardie. Mr. Robin resides at 17, Broom Road, Newlands, Glasgow, S.3.

CATALOGUES

HADFIELDS, Ltd., Sheffield.—A pamphlet on "Hadmang" electrodes and welding rods.

BAKELITE, Ltd., Brackley Lodge, Brackley, Northants.—A booklet on laminated sheets, rods, and tubes.

ELECTRIC CONSTRUCTION COMPANY, Ltd., Lamport Hall, Northampton.—Booklet B 1204 on metal rectifiers.

W. EDWARDS AND CO. (London), Ltd., Southwell Road, S.E.5.—Catalogue on rotary pumps for the production of high vacua.